MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

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J. W. L. GLAISHER, Sc.D., F.R.S., President, in the Chair.

Edward E. Barnard, M.A., Lick Observatory, Mount Hamilton, California, U.S.A.;
William R. Brooks, Red House Observatory, Phelps, N.Y., U.S.A.;
Captain Leonard Darwin, R.E., 18 Wetherby Place, South Kensington, S.W.;
James Gill, 2 Beech Mount, Fairfield, Liverpool;
William B. Hutchinson, The Observatory, Liversedge, Yorkshire;
George James Jacobs, Lansdowne, Guildford, Surrey;
Rev. Joseph Walshe, St. Edward's College, Liverpool; and
Francis James Wardale, 1 Whitehall Place, S.W.,

were balloted for and duly elected Fellows of the Society.

Request to Observers of Variable Stars. By Professor J. A. C. Oudemans.

(*Extract from a letter to the Secretary.*)

Being occupied in deducing new elements of *Algol* for the second volume of Kaiser's "Sterrenhemel," I am much disappointed by the fact that observers of variable stars do not hasten to publish their observations. You would oblige me very much by communicating my general request that observers of the minima of *Algol* would send me their results, especially those obtained since 1883.

Utrecht: 1888, *January* 11.

Day, 1887	Correction to be subtracted from M.T. for change of Sidereal Time at Mean Noon since 1864.	Observer.	Observed R.A.	Seconds of Hansen's R.A.	Hansen *minus* Observed. **Uncorrected** for Error in Time.	Correction due to Error in Time.	Hansen *minus* Observed. **Corrected** for Error in Time.	Observed N.P.D.	Seconds of Hansen's N.P.D.	Hansen *minus* Observed. **Uncorrected** for Error in Time.	Correction due to Error in Time.	Hansen *minus* Observed. **Corrected** for Error in Time.
	s		h m s	s	s	s	s	° ′ ″	″	″	″	″
May 5	34·68	F. B.	13 28 42·40	43·31	+0·91	−1·36	−0·45	94 43 34·49	39·20	+4·71	−7·01	−2·30
7	34·68	F. B.	15 27 57·62	58·99	+1·37	−1·40	−0·03	103 41 59·31	64·92	+5·61	−5·15	+0·46
9	34·69	R.	17 29 28·81	30·02	+1·21	−1·40	−0·19	108 51 52·73	54·17	+1·44	−1·91	−0·47
12	34·70	R.	20 22 11·07	12·40	+1·33	−1·25	+0·08	107 40 24·67	23·96	−0·71	+2·72	+2·01
13	34·71	F. B.	21 14 39·38	40·93	+1·55	−1·19	+0·36	105 19 50·22	46·33	−3·89	+3·79	−0·10
June 4	34·80	R.	15 59 49·23	50·45	+1·22	−1·40	−0·18	105 30 30·36	33·10	+2·74	−4·43	−1·69
8	34·81	F. B.	19 57 39·42	40·82	+1·40	−1·31	+0·09	108 39 53·85	53·31	−0·54	+2·15	+1·61
9	34·82	W.	20 52 23·57	24·99	+1·42	−1·25	+0·17	106 39 49·37	47·57	−1·80	+3·41	+1·61
10	34·82	F. B.	21 44 18·38	20·14	+1·76	−1·18	+0·58	103 52 52·63	49·23	−3·40	+4·36	+0·96
30	34·90	R.	14 39 36·61	37·46	+0·85	−1·33	−0·48	100 11 41·85	45·76	+3·91	−6·01	−2·10
July 2	34·91	R.	16 35 35·93	37·16	+1·23	−1·38	−0·15	107 8 9·46	11·90	+2·44	−3·52	−1·08
5	34·92	F. B.	19 32 36·92	38·48	+1·56	−1·34	+0·22	109 18 55·95	55·14	−0·81	+1·47	+0·66
7	34·93	F. B.	21 22 21·37	22·83	+1·46	−1·23	+0·23	105 17 50·40	46·02	−4·38	+3·99	−0·39
27	35·01	R.	14 22 49·38	50·26	+0·88	−1·32	−0·44	98 46 25·26	31·36	+6·10	−6·25	−0·15
29	35·02	R.	16 16 34·11	35·17	+1·06	−1·35	−0·29	106 10 53·08	55·69	+2·61	−3·97	−1·36
30	35·02	F. B.	17 14 38·08	39·44	+1·36	−1·37	−0·01	108 28 7·39	10·38	+2·99	−2·44	+0·55
Aug. 1	35·03	F. B.	19 10 42·80	43·89	+1·09	−1·34	−0·25	109 36 33·10	32·59	−0·51	+0·83	+0·32
2	35·03	R.	20 7 2·45	3·58	+1·13	−1·30	−0·17	108 29 9·92	6·92	−3·00	+2·30	−0·70
3	35·04	F. B.	21 1 17·31	18·67	+1·36	−1·25	+0·11	106 23 32·93	29·80	−3·13	+3·56	+0·43
4	35·04	R.	21 53 11·14	12·25	+1·11	−1·20	−0·09	103 30 61·57	57·28	−4·29	+4·53	+0·24
7	35·05	R.	0 17 2·73	3·96	+1·23	−1·09	+0·14	92 10 6·27	1·75	−4·52	+5·83	+1·31

Day, 1887.	Correction to be subtracted from M.T. for change of Sidereal Time at Mean Noon since 1864.	Observer.	Observed R.A.	Seconds of Hansen's R.A.	Hansen *minus* Observed. **Uncorrected** for Error in Time.	Correction due to Error in Time.	Hansen *minus* Observed. **Corrected** for Error in Time.	Observed N.P.D.	Seconds of Hansen's N.P.D.	Hansen *minus* Observed. **Uncorrected** for Error in Time.	Correction due to Error in Time.	Hansen *minus* Observed. **Corrected** for Error in Time.
	s		h m s	s	s	s	s	° ′ ″	″	″	″	″
Aug. 25	35·12	F. B.	15 59 3·71	5·08	+1·37	−1·36	+0·01	105 16 33·77	36·03	+2·26	−4·43	−2·17
27	35·13	F. B.	17 55 7·46	8·83	+1·37	−1·36	+0·01	109 23 47·99	47·70	−0·29	−1·30	−1·59
Sept. 28	35·26	R.	22 9 17·36	18·42	+1·06	−1·17	−0·11	102 30 21·51	16·61	−4·90	+4·79	−0·11
Oct. 10	35·31	R.	8 11 2·51	3·62	+1·11	−1·38	−0·27	71 24 34·29	37·08	+2·79	−2·60	+0·19
24	35·36	W.	21 2 17·73	18·96	+1·23	−1·25	−0·02	106 38 16·87	12·71	−4·16	+3·64	−0·52
25	35·37	R.	21 53 33·64	34·71	+1·07	−1·19	−0·12	103 44 11·59	6·13	−5·46	+4·59	−0·87
28	35·38	R.	0 15 46·65	47·65	+1·00	−1·09	−0·09	92 17 42·16	36·98	−5·18	+5·98	+0·80
31	35·39	W.	2 34 23·99	24·98	+0·99	−1·13	−0·14	80 4 59·97	55·64	−4·33	+5·35	+1·02
Nov. 1	35·40	R.	3 22 43·74	44·86	+1·12	−1·17	−0·05	76 34 3·75	0·47	−3·28	+4·67	+1·39
4	35·41	R.	5 59 2·08	2·98	+0·90	−1·30	−0·40	70 3 52·53	49·69	−2·84	+1·18	−1·66
24	35·49	F. B.	0 0 2·06	3·14	+1·08	−1·10	−0·02	93 56 31·67	29·22	−2·45	+5·99	+3·54
29	35·51	R.	3 55 30·82	31·67	+0·85	−1·21	−0·36	74 31 13·99	9·46	−4·53	+4·22	−0·31
Dec. 8	35·54	R.	12 14 6·89	7·90	+1·01	−1·32	−0·31	87 12 14·17	17·30	+3·13	−7·27	−4·14
23	35·60	R.	1 13 56·56	57·44	+0·88	−1·10	−0·22	87 20 27·58	22·73	−4·85	+6·08	+1·23
26	35·62	R.	3 35 43·63	44·28	+0·65	−1·20	−0·55	75 49 38·90	34·59	−4·31	+4·64	+0·33
27	35·62	W.	4 26 50·45	51·37	+0·92	−1·25	−0·33	72 55 40·01	36·19	−3·82	+3·65	−0·17
28	35·62	F. B.	5 20 27·93	28·85	+0·92	−1·31	−0·39	70 48 39·40	35·61	−3·79	+2·39	−1·40
					s		s					
Mean of Errors, without regard to sign			... ...		**1·057**	...	**0·291**	... ...	...	**3″·191**	...	**1″·229**
Mean Errors for Year			... ...		... + **1·057**	...	**−0·214**					

Observers: W., Mr. W. Wickham; R., Mr. W. H. Robinson; F. B., Mr. F. A. Bellamy.

TABLE II.

Radcliffe Observations of the Moon, 1887.

Errors of the Moon's Tabular Place in Longitude and Ecliptic Polar Distance, "Uncorrected" and "Corrected" for the change in Tabular Mean Time introduced in the year 1864.

Day.		Errors of Longitude (Hansen *minus* Observed).		Errors of E.N.P.D. (Hansen *minus* Observed).	
		Uncorrected.	Corrected.	Uncorrected.	Corrected.
1887.					
Jan.	4	+11″·85	−6″·06	+1″·43	+0″·88
	5	+13·15	−5·38	−0·03	−0·24
	6	+10·87	−8·20	−0·22	+0·02
	12	+19·88	−0·99	−6·77	−4·89
	16	+17·14	−2·50	−1·99	−1·29
Jan.	31	+9·07	−8·37	−1·56	−2·21
Feb.	1	+9·94	−7·92	−0·95	−1·25
	2	+13·72	−4·71	−1·70	−1·64
	4	+8·56	−11·08	−2·07	−1·15
	5	+11·82	−8·46	−1·78	−0·52
	7	+15·05	−6·24	−1·60	+0·30
Feb.	28	+10·67	−6·70	+0·04	−0·35
March	2	+7·40	−10·92	−3·40	−2·15
	3	+8·51	−10·26	−1·19	−0·52
	4	+10·69	−8·74	−2·81	−1·71
April	7	+16·84	−5·06	−1·37	−0·04
May	5	+14·42	−7·12	−0·66	+0·35
	7	+20·81	−0·31	+0·54	+0·55
	9	+17·26	−2·72	+0·53	−0·33
	12	+18·67	+0·65	+3·71	+2·22
	13	+22·55	+5·00	+2·97	+1·46
June	4	+17·90	−2·90	−0·84	−1·14
	8	+19·66	+0·94	+3·38	+1·83
	9	+20·11	+1·91	+3·81	+2·21
	10	+25·31	+7·65	+5·24	+3·69
June	30	+13·20	−7·42	−0·12	+0·17

Day.		Errors of Longitude (Hansen *minus* Observed). Uncorrected.	Corrected.	Errors of E.N.P.D. (Hansen *minus* Observed). Uncorrected.	Corrected.
		"	"	"	"
1887. July	2	+17·88	− 2·29	−0·12	−0·76
	5	+21·95	+ 2 97	+2·65	+1·14
	7	+21·42	+ 3 28	+2 32	+0 65
July	27	+14·39	− 6·25	+1·54	+1·98
	29	+15·56	− 4·37	−0 10	−0·61
	30	+19·58	+ 0·19	+1·44	+0·56
Aug.	1	+15·39	− 3·55	+1·35	−0·11
	2	+16·36	− 2·22	+0·45	−1·19
	3	+19·65	+ 1·39	+2·55	+0·86
	4	+16·69	− 1·32	+1·46	−0·22
	7	+18·80	+ 1·41	+3·19	+2·04
Aug.	25	+19·97	− 0·30	−1·76	−2·16
	27	+19·41	+ 0·14	−0·43	−0·59
Sept.	8	+16·26	− 1·47	+0·89	−0·67
Oct.	10	+16·03	− 3·71	−0·70	+1·02
Oct.	24	+18·15	− 0·13	+1·03	−0·58
	25	+16·53	− 1·35	+0·17	−1·41
	28	+15·88	− 1·56	+1·20	+0·20
	31	+15·31	− 2·29	+0·46	+0·32
Nov.	1	+16·70	− 1·06	+0·98	+1·16
	4	+12·71	− 5·65	−2·84	−1·66
Nov.	24	+15·83	− 1·69	+4·24	+3·30
	29	+13·00	− 5·04	−1·91	−1·37
Dec.	8	+15·21	− 5·94	−3·15	−1·96
Dec.	23	+14·10	− 3 53	+0·51	−0 11
	26	+10·24	− 7·88	−1·97	−1·56
	27	+13·68	− 4·66	−1·68	−0·92
	28	+13·29	− 5·42	−2·88	−1·78
Mean of Errors, without regard to sign		**...15″·649**	**4″·246**	**1″·754**	**1″·184**
Mean Errors for Year		**+15″·649**	**−3″·299**		

TABLE III.

Mean Excess over Observation of the Moon's Tabular Place in Longitude for the years 1847 *to* 1887, *as computed from Hansen's Tables.*

"Uncorrected" and "Corrected" on and after 1864 *for the change in Tabular Mean Time, introduced in the year* 1864.

Year.	Errors of Longitude (Hansen *minus* Observed). Uncorrected.	Corrected.
	″	″
1847	+ 1·07	+ 1·07
1848	+ 0·20	+ 0·20
1849	− 0·47	− 0·47
1850	− 0·28	− 0·28
1851	− 1·29	− 1·29
1852	− 0·92	− 0·92
1853	− 1·63	− 1·63
1854	− 1·68	− 1·68
1855	− 0·87	− 0·87
1856	− 0·96	− 0·96
1857	− 1·86	− 1·86
1858	− 1·98	− 1·98
1859	− 1·80	− 1·80
1860	− 2·90	− 2·90
1861	− 2·19	− 2·19
1862	− 2·83	− 2·83
1863	− 1·61	− 1·61
1864	+ 0·12	− 0·81
1865	+ 1·27	− 0·22
1866	+ 2·14	− 0·22
1867	+ 3·48	+ 0·36
1868	+ 4·12	+ 0·28
1869	+ 4·28	− 0·35
1870	+ 4·83	− 0·66
1871	+ 6·96	+ 0·44
1872	+ 7·31	+ 0·10
1873	+ 8·24	+ 0·20
1874	+ 9·29	+ 0·56
1875	+ 9·87	+ 0·36
1876	+ 9·80	− 0·51
1877	+ 9·23	− 1·90
1878	+ 8·22	− 3·60
1879*	+ 9·63	− 3·12
1880	+ 10·89	− 2·77
1881	+ 10·51	− 4·06
1882†	+ 12·68	− 2·51
1883	+ 14·71	− 1·50
1884	+ 14·65	− 1·91
1885	+ 15·14	− 1·87
1886	+ 15·34	− 2·53
1887‡	+ 15·65	− 3·30

* All to 1879, Greenwich observations.
† 1880 to 1882, Mean of Greenwich and Radcliffe.
‡ 1883 and since, Radcliffe only.

Radcliffe Observatory, Oxford:
1888, *January* 9.

Note on the Total Solar Eclipse of 1889, *January* 1.

By J. R. Hind, LL.D., F.R.S.

The belt of totality in the solar eclipse on January 1 next traverses California, where at that season favourable atmospheric conditions for observation may be anticipated with some degree of confidence.

The central line meets the American coast at Point Arena, traversing the State of California in the direction of Pilot Peak, which is also close upon the central eclipse. At Point Arena totality commences at $1^h\ 30^m\ 33^s$ local mean time, or at $1^h\ 45^m\ 13^s$ Pacific standard time, and continues $2^m\ 3^s$ according to the elements of the *Nautical Almanac*, the Sun at an altitude of 25°. At Pilot Peak totality commences at $1^h\ 45^m\ 54^s$ local mean time, or at $1^h\ 49^m\ 46^s$ Pacific standard time, and continues $1^m\ 57^s$, with the Sun at an altitude of 23°. Between these points the central eclipse crosses the track of the Central Pacific Railroad, or rather branches of that line, north of Colusa. Probably any observers proceeding from Europe for the observation of this phenomenon will not care to locate themselves east of the Sierra Nevada, the duration of totality of course diminishing with decreasing westerly longitude, and the Sun's altitude also becoming less, so that in 105° 29′ W. and 46° 39′ N., close on the central line, the total eclipse begins at $3^h\ 4^m\ 14^s$ local mean time, and continues $1^m\ 25^s$, with the Sun at an altitude of only 9°. The main line of the Central Pacific appears to be again crossed near Oreana.

At Mendocino totality commences at $1^h\ 29^m\ 47^s$ local mean time, and continues $1^m\ 45^s$. At San Francisco and its suburbs Alameda, Oakland, and Berkeley (the seat of the University of California, now presided over by our associate Prof. Holden), the eclipse, though very large, will not be total. At San Francisco the magnitude is 0·987, and it is to be regretted that the Lick Observatory on Mount Hamilton is not within the shadow; the greatest eclipse occurs there at $1^h\ 45^m$ local mean time, magnitude 0·974.

For any place near Point Arena the *Greenwich* mean time (t) of beginning and ending of totality may be found from the following expressions:—

$$\cos\omega = +125{\cdot}9912 - [2{\cdot}14556]\sin l + [1{\cdot}75929]\cos l\,.\,\cos(\lambda + 334^\circ\ 32'{\cdot}6)$$

$$t = 8^h\ 54^m\ 7^s{\cdot}6 \mp [1{\cdot}78807]\sin\omega + [2{\cdot}72053]\sin l - [3{\cdot}96675]\cos l\cos(\lambda + 236^\circ\ 27'{\cdot}3)$$

where l is the *geocentric* latitude of the place, λ the longitude west of Greenwich, taken *negatively*, and the quantities within the square brackets are logarithms.

The track of the central eclipse between $9^h\ 45^m$ and $10^h\ 0^m$ Greenwich mean time is as follows:—

Greenwich M.T.	Long. W.	Lat. N.	Duration of Totality on Central Line	Sun's Altitude
h m	° ′	° ′	m s	°
9 45·0	124 21·7	38 44·6	2 4·1	25·5
9 47·5	122 56·4	39 11·7	2 1·3	24·5
9 50·0	121 25·9	39 42·5	1 58·1	23·3
9 52·5	119 49·3	40 17·7	1 54·6	22·0
9 55·0	118 4·8	40 58·3	1 50·9	20·6
9 57·5	116 9·7	41 45·6	1 46·9	19·0
10 0·0	114 0·5	42 41·2	1 42·7	17·1

The Opposition of Sappho (80) *in* 1888.

By Robert Bryant, B.A., B.Sc.

This planet comes into opposition in longitude about 1888, April 1·2. The usual opportunity will then be afforded for obtaining the observations requisite for the correction of the elements of the planet's orbit. And that these observations should be made seems highly desirable for two reasons. Firstly, the observations of this planet between the years 1872 and 1882 were very few, so that this somewhat long neglect of the planet strengthens its claim for re-observation; and secondly, in August and September 1889 the planet makes one of those near approaches to the Earth which, on account of the eccentricity of its orbit and the near commensurability of its period with that of the Earth, occur every seven years.

For this purpose the following ephemeris for Greenwich midnight has been prepared, to which is added a suitable list of comparison stars, of which observers are requested to make use.

Observers using the transit instrument for observation of the planet may also be able to observe the corresponding comparison star.

☍ in Longitude, 1888, April 11·7.

Magnitude 11.

Greenwich Midnight. 1888.	Right Ascension. h m s	Declination. ° ′ ″	Log Δ.	Aberration. m s	Comp. Star.
Mar. 27	13 34 19·00	−14 26 34·7	0·23956	14 24	21
28	33 30·18	−14 19 51·0			20
29	32 40·47	−14 12 58·3	0·23677	14 19	20
30	31 49·93	−14 5 56·5			19
31	30 58·61	−13 58 45·9	0·23425	14 14	19
April 1	30 6·57	−13 51 26·9			18

Greenwich. Midnight. 1888.	Right Ascension. h m s	Declination. ° ′ ″	Log Δ.	Aberration. m s	Comp. Star.
April 2	13 29 13·87	−13 43 59·9	0·23198	14 10	17
3	28 20·56	−13 36 25·1			17
4	27 26·71	−13 28 42·9	0·23001	14 5	14
5	26 32·38	−13 20 53·7			14
6	25 37·63	−13 12 57·8	0·22830	14 2	16
7	24 42·53	−13 4 55·7			16
8	23 47·13	−12 56 47·8	0·22688	13 59	15
9	22 51·51	−12 48 34·5			15
10	21 55·72	−12 40 16·3	0·22577	13 57	13
11	20 59·85	−12 31 53·6			13
12	20 3·96	−12 23 27·0	0·22494	13 56	12
13	19 8·12	−12 14 57·0			11
14	18 12·40	−12 6 24·0	0·22441	13 55	10, 11
15	17 16·87	−11 57 48·6			10
16	16 21·58	−11 49 11·2	0·22419	13 54	9
17	15 26·61	−11 40 32·5			9
18	14 32·01	−11 31 52·9	0·22426	13 54	8
19	13 37·85	−11 23 12·9			8
20	12 44·18	−11 14 33·0	0·22462	13 55	6
21	11 51·07	−11 5 53·7			6
22	10 58·57	−10 57 15·5	0·22528	13 57	7
23	10 6·75	−10 48 28·9			7
24	9 15·63	−10 40 4·3	0·22622	13 58	5
25	8 25·30	−10 31 32·4			4, 5
26	7 35·78	−10 23 3·4	0·22743	14 0	4
27	6 47·14	−10 14 38·0			2
28	5 59·41	−10 6 16·4	0·22492	14 3	1, 2
29	5 12·66	− 9 57 59·1			3
30	13 4 26·91	− 9 49 46·6	0·23066	14 7	3

Comparison Stars.

No.	Mag.	R.A. 1888·0. h m s	δ 1888·0. ° ′ ″	Authority.	Date for use.
1	5·8	13 2 1·40	−10 8 24·0	B.A. Cat. Lamont	Apr. 28
2	8·3	4 39·95	−10 13 0·7	Santini	27, 28
3	8·0	5 28	− 9 54·7	D.M. −9° 3641	29, 30
4	9·6	8 52·13	−10 25 18·4	Lamont	25, 26
5	8·7	10 3 98	−10 38 50·2	Paris, 1882	24, 25
6	8·7	10 56 99	−11 10 39·0	Weisse, Santini	20, 21

No.	Mag.	R.A. 1888·0 h m s	δ 1888·0 ° ′ ″	Authority.	Date for use.
7	6·7	13 11 28·86	−10 53 35·0	Gould's Cat.	22, 23
8	7·5	12 56·35	−11 25 30·0	Weisse, Santini	18, 19
9	9·2	14 28	−11 46·7	D.M. −11° 3493	16, 17
10	7	16 12·96	−11 59 32·0	Gould, Paris, 1870	14, 15
11	5	20 48·35	−12 7 27·8	Gould, Yarn. (*i Virginis*)	13, 14
12	9·0	21 32·25	−12 23 25·5	Santini, Lamont	12
13	9·5	21 35	−12 35·5	D.M. −12° 3819	10, 11
14	8·7	24 0·46	−13 25 21·0	Weisse, Santini, Lamont	4, 5
15	7	25 16·70	−12 52 15·0	Gould, Paris, 1870	8, 9
16	9·7	25 47	−13 8·6	D.M. −12° 3834	6, 7
17	8·9	27 26·12	−13 40 13·5	Weisse, Santini	2, 3
18	9·5	31 26	−13 51·6	D.M. −13° 3733	1
19	7·8	32 1·61	−14 1 16·2	Paris, 1855, 1879	Mar. 30, 31
20	9·2	32 26	−14 16·6	D.M. −14° 3763	28, 29
21	8	13 36 52·78	−14 28 7·8	Paris, 1882, 1883	27

Precession for 1888·0 *of the above stars.*

No.	Prec. R.A. s	Prec. δ. ″	No.	Prec. R.A. s	Prec. δ. ″
1	+3·135	−19·32	12	+3·174	−18·79
2	+3·139	−19·26	13	+3·175	−18·79
3	+3·137	−19·24	14	+3·186	−18·72
4	+3·144	−19·15	15	+3·182	−18·68
5	+3·147	−19·12	16	+3·185	−18·66
6	+3·152	−19·10	17	+3·192	−18·61
7	+3·150	−19·08	18	+3·199	−18·47
8	+3·156	−19·04	19	+3·202	−18·46
9	+3·160	−19·00	20	+3·205	−18·44
10	+3·164	−18·95	21	+3·213	−18·29
11	+3·170	−18·82			

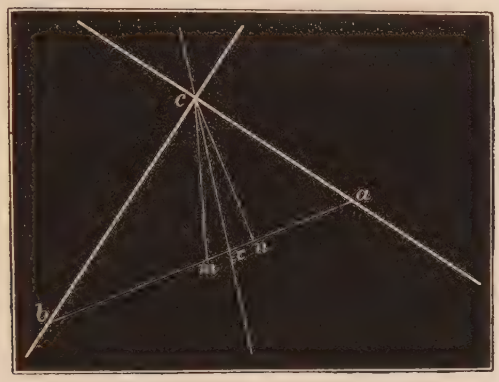
Observers are requested to publish their observations as early as possible, so that the final corrections of the assumed elements of the planet's orbit may be obtained.

On the Cross Reticule. By G. L. Tupman.

Of the various devices for utilising the diurnal motion of the Earth for micrometric measurements, without the aid of artificial light, a reticule of two straight, stout wires or bars crossing each other at right angles at the centre of the field,

and *admitting of being accurately oriented*, offers the greatest convenience in practice.

The simple theory of such a reticule may be thus stated :—



Let *ca*, *cb* be two wires inclined to one another at any angle 2γ, forming a simple cross reticule, of which *cx* is the axis lying nearest to an hour-circle, *cn*; let this axis make any angle θ (less than γ) with the hour-circle; let *ab*, perpendicular to *cn*, be the path of a star near the meridian across the reticule, and *m* the middle point of *ab*. Then $acx = \gamma$, $ncx = \theta$, and $mcx = y$ suppose.

The mean of the recorded times of transit at *a* and *b* will be the time of passing the point *m*; but in order to compare two stars in R.A. their transits over the hour-circle *cn* must be compared. Hence the time of describing the distance *nm* must be applied to the mean of the observed times in order to know the instant of passing the point *n*.

Now

$$\sin y = \tan\theta \,.\, \tan^2\gamma$$

$$cn = \frac{\frac{1}{2}ab \,.\, \cos(\gamma+\theta)\cos(\gamma-\theta)}{\sin(\gamma+y)},$$

and

$$mn = cn \,.\, \tan(y+\theta).$$

If now $\gamma = 45°$ and θ be small, we shall have

$$y = \theta$$

$$cn = \tfrac{1}{2}ab$$

$$mn = \tfrac{1}{2}ab \sin 2\theta.$$

These simple expressions show the advantage of using wires at right angles, each inclined *nearly* 45° to the hour-circle, and by-and-by we shall see that some of the small corrections are thereby reduced to their simplest form.

A great advantage of this form of reticule is that the centre

portion of the field of view, where definition is best, is most used; and the wires being radial are in the best possible position for being sharply defined by the eyepiece.

The bars of my reticule are of watch-spring one-third of a millimeter broad. I had no difficulty in selecting two pieces with perfectly straight edges. The circular aperture of the diaphragm is one inch, over which the bars are held in position by screws. The eyepiece is of the Ramsden form, about $1\frac{1}{4}$ inch focus, the lenses of which are placed a little nearer together than is usual, thus enlarging the available field.

If it were intended to use such a reticule without a position-circle, it would be necessary to place a fibre of silk between the bars and bisecting, as nearly as possible, one pair of the angles. The exact angles which the bars make with the fibre would then have to be carefully determined by observations of selected stars.

The sliding tube which carries the reticule must be fitted with a ring-clamp, on which is a stud or projection fitting cleanly into a corresponding notch in the revolving central portion of the position-circle, so that the connection between the bars and the verniers is rigid, and the zero preserved when the eyepiece is withdrawn.

As soon as the Sun has set,* the telescope should be pointed on rather a bright star near the equator with a small easterly hour-angle. A few minutes will then suffice to adjust the reticule exactly to focus and approximately oriented when the position-circle has any given reading. The ring-clamp can then be tightened, which will permanently fix the bars in focus and in relation to the verniers of the position-circle.

One bar being approximately parallel to the direction of the diurnal motion, bring the star to the centre of the field, and, by means of the slow motion in declination, bisect it with an edge of the said bar, then quickly shifting the telescope so that the star is on the extreme preceding side of the field, turn the position-circle centre until the star is again bisected by the same edge. Allow the star to traverse the field and alter the position of the bar until the star remains bisected along the entire length of the bar.† Then read both verniers of the position-circle.

In this manner the readings of the position-circle are obtained when both edges of both bars are truly oriented. It will be found easy to have a discordance of 3′ in any one reading, hence this must be done often to ensure obtaining the angle between the bars with the accuracy desirable, say 1′.

At Harrow, with the telescope on the *East* side of the pillar, the mean reading for bar A was 0° 2′·8; for bar B 89° 51′·8.

* If this be done at night the field of view must be illuminated; but these observations can be made exceedingly well by using the trapezium in the Great Nebula of *Orion*, without artificial illumination.

† If the polar axis of the equatorial be well adjusted, these observations can be more quickly made by swinging backwards and forwards in R.A. with the slow motion.

The position-circle being graduated in the order N*f*S*p*, when its setting is 44° 57′·3 (the zero of orientation) the axis of the larger angle, 90° 11′, will coincide with the hour-circle—in other words, the reticule will be correctly oriented with its larger angle placed for measuring differences of declination.

The zero of orientation thus obtained cannot be used with any other pointing of the telescope unless the observer has satisfied himself that flexure produces no sensible effect.

When the instrument used above was reversed to the *West* side of the pillar, it was found that the bar A was correctly oriented when the reading was 0° 14′·5, repeated reversals giving the same result. This indicates a coefficient of flexure of 8′, a quantity much too large to be neglected.* In practice the flexure is got rid of by obtaining the zero of orientation with the telescope pointing nearly in the same direction as during the comparisons for which the zero is required.

If the zero be obtained by swinging the polar axis it will be the *true* zero; but if obtained by allowing the star to traverse the field of its own motion, it will be the *apparent* zero and affected by refraction. It is immaterial which is used in the reductions until the correction for refraction has to be computed; of which more anon.

Reduction of Observations.

Let t_1, t_2 be the sidereal clock times of transit over the middle of the bars, that is the mean of disappearance and reappearance.

T, the mean $= \frac{1}{2}(t_2 + t_1)$.

τ, the half difference $= \frac{1}{2}(t_2 - t_1)$, considered negative if the object be north of the centre.

D, the distance of the middle point of the path described from the centre of the reticule $= 15\,\tau \sin P$.

P, the N.P.D. of the object; or, if used without a suffix, the mean N.P.D. of the two objects.

ΔR.A., ΔN.P.D. the differences of R.A. and N.P.D., and let it be supposed throughout that the southern object is the known, and it is required to find the place of the northern object—the objects being indicated by the suffixes N and S.

Then the approximate

$$\Delta \text{ R.A.} = T_N - T$$

* Bessel, *Astr. Untersuchungen*, i. 14 and ii. 5.

and approximate

$$\Delta \text{ N.P.D.} = D_N - D_S$$
$$= 15\,(\tau_N - \tau)\,\sin P$$

unless too near the pole.

If R be the actual setting of the position-circle (supposed to be graduated in the direction N*f*S*p*), and Z the zero of orientation (either true or apparent), the error of orientation (θ) is obtained with its correct sign from

$$\theta = R - Z.$$

Then the time of describing *mn* (of the figure) is

$$2\tau \sin \theta,$$

and for the N. star the

$$\text{corrected } T_N = T_N + 2\tau_N \sin \theta,$$

and for the S. star the

$$\text{corrected } T_S = T_S + 2\tau_S \sin \theta,$$

and, hence the correction required to ΔR.A. for defective orientation is

$$+ 2(\tau_N - \tau_S) \sin \theta.$$

If $90° + \eta$ be the N. and S. angle of the reticule, the correction required to ΔN.P.D. is

$$-\Delta \text{ N.P.D.} \cdot \sin \eta,$$

η being constant, a small table may be formed of this correction.

If one of the objects have a proper motion $d\alpha$ and dD in R.A. and N.P.D. in 1^s of time, the correction required to ΔN.P.D. is

$$-15\tau \cdot d\alpha \cdot \sin P,$$

and the correction required to ΔR.A. is

$$+ \frac{\tau \cdot d\text{D}}{15\,(1 - \Delta\alpha) \sin P}$$

where τ has the value proper to the object, and is negative if on north side.

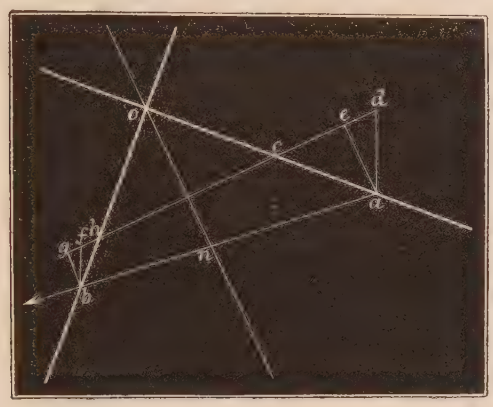
The curvature of path will generally be sensible; the correction required to ΔN.P.D. on this account is

$$-[6.7367]\,(\tau_N + \tau_S)(\tau_N - \tau_S) \sin P \cdot \cos P.$$

Correction for Refraction.

Let the stars be east of the meridian; *on* the axis of the reticule exactly oriented; *ao*, *bo* the bars; *ab* the observed path of a star in the inverted field, as affected by refraction; *ad* and

bf, perpendicular to the horizon, the refraction at *a* and *b* respectively. Join *df* and make *ae*, *bg* perpendicular to *dg*, and therefore parallel to *on*.



Then if there were no refraction the star would transit the path *dchg* perpendicular to *on*. *de*, *fg* are the refractions in R.A. which we will call a_1, a_2; *ae*, *bg* are the refractions in N.P.D. which we will call d_1, d_2. In the sense of reducing apparent to true place, the refractions in R.A. are positive when east of the meridian; the refractions in N.P.D. are always positive in the northern hemisphere except in a limited area between the pole and zenith.

Had there been no refraction the star would have been seen at *d* at the instant (t_1) when it was at *a*, and it would have arrived at the point *c* later than t_1 by the time of describing

$$dc\,(=de+ec)=a_1+\frac{d_1}{15\sin P}.$$

Similarly the star would have been seen at *h* earlier than at *b* by the time of describing

$$hf\,(=hg-fg)=-a_2+\frac{d_2}{15\sin P}.$$

Therefore

$$\text{corrected } t_1=t_1+a_1+\frac{d_1}{15\sin P};$$

$$\text{corrected } t_2=t_2+a_2-\frac{d_2}{15\sin P}.$$

Hence

$$\text{corrected T}=\tfrac{1}{2}(t_2+t_1)+\tfrac{1}{2}(a_2+a_1)-\tfrac{1}{2}(d_2-d_1)\frac{1}{15\sin P},$$

and

$$\text{corrected }\tau=\tfrac{1}{2}(t_2-t_1)+\tfrac{1}{2}(a_2-a_1)-\tfrac{1}{2}(d_2+d_1)\frac{1}{15\sin P}.$$

Putting now a and d for the refractions at the middle point of the path, δa, δd, the increase of these quantities respectively in two minutes of time (to be explained further on), we have, assuming the refractions to vary symmetrically over the portion of the field utilised,

$$\text{corrected T} = \text{T} + a - \frac{\tau}{120} \cdot \frac{\delta d}{15 \sin \text{P}};$$

$$\text{corrected } \tau = \tau - \frac{d}{15 \sin \text{P}} + \frac{\tau}{120} \delta a,$$

and therefore the correction to $\triangle$R.A. is

$$+ (a_{\text{N}} - a_{\text{S}}) - \frac{\tau_{\text{N}} - \tau_{\text{S}}}{120} \cdot \frac{\delta d}{15 \sin \text{P}},$$

and the correction to ΔN.P.D. is

$$- (d_{\text{N}} - d_{\text{S}}) + \frac{\tau_{\text{N}} - \tau_{\text{S}}}{120} \delta a \, . \, 15 \sin \text{P}.$$

With proper attention to the signs of these quantities the above expressions will be correct under all circumstances, within the limits of the assumption that the change of refraction is proportional to the time in all parts of the field, an assumption that can hardly ever introduce sensible error.

At all observatories auxiliary tables are used for facilitating the computation of refraction for extra-meridional observations. The most simple are thus formed :—

Let ZM be the perpendicular from the apparent zenith Z on the hour-circle passing through the star, and PM the arc included between the pole and the foot of the perpendicular; then

$$\sin \text{ZM} = \sin \text{hour-angle} \times \sin \text{colat.}$$

$$\tan \text{PM} = \cos \text{hour-angle} \times \tan \text{colat.}$$

The angle PM, in degrees and minutes, and the log. tan ZM are tabulated with argument every two minutes of hour-angle; the calculations of the refractions in R.A. and N.P.D. are then readily made from

$$\text{Mean refraction in R.A. in seconds of time} = \frac{[0{\cdot}5836] \tan \text{ZM}}{\sin \text{N.P.D.} \, . \, \cos (\text{N.P.D.} - \text{PM})}.$$

$$\text{Mean refraction in N.P.D. in seconds of arc} = [1{\cdot}7597] \tan (\text{N.P.D.} - \text{PM}).$$

If desired, these refractions can in a moment be corrected for pressure and temperature of the atmosphere.

The refractions are to be computed for the common hour-angle corresponding to the time, T, and the N.P. distances of either object, which give the four quantities a_{N}, d_{N}, a_{S}, d_{S}. Then adding two minutes to the time, T, the refractions are again computed for one of the objects, and hence are obtained δa and δd.

It is to be noted that the quantities a and d are common to

all differential work, being the refractions depending on N.P.D. The second terms depend upon the variation of the refractions with hour-angle, and are reduced to their simplest form because the bars are inclined 45° to the hour-circle.

If the *apparent* zero of orientation has been employed in the reductions, the second term of the refraction correction in R.A. disappears because the apparent path of the stars is perpendicular to the axis of the reticule.

As an example I will quote an extreme case that occurred at Harrow when observing the Comet *Barnard*, on 1886, April 8.

	h	m	s		°	′	″
Local sid. time	10	27	7	Colat.	38	25	2
approx. R.A.	1	48	34	N.P.D.	56	14	7
✶ „ „	1	47	3	„	56	4	1

Approx. Δ R.A. + 1 30·94, Δ N.P.D. − 10′ 28″·9.

The mean refractions are :—

		s	″
At 10 27		−20·72	+469·5
„	✶	−20·28	+458·5
10 29	✶	−20·77	+474·0

Whence

$$\delta a = -0^{s}\cdot 49 \quad \delta d = +15''\cdot 5.$$

The mean

$$\tau_N - \tau_S = -50^{s}\cdot 6,$$

and, therefore, attending to the signs and remarking that the comet is the *southern* object, we have the corrections for refraction :—

	s	″
First term	−0·44	+11·0
Second term	+0·52	− 2·6
	+ ·08	+ 8·4

If the reticule had been oriented by the apparent motion of the stars the corrections would have been

$$-0^{s}\cdot 44 \qquad +8''\cdot 4.$$

Harrow : 1888, *January.*

Note on the Definition of Reflecting Telescopes and on the Images of Bright Stars on Photographic Plates. By Lieut.-General J. F. Tennant, R.E., F.R.S.

It has frequently been said that the images of stars are seen in reflecting telescopes without any diffraction rings surrounding them. This statement has always surprised me, because it is accompanied by the statement that the discs are very small compared with those in reflectors. The theoretical investigation which accounts for the rings assumes that the optical rays are rigorously convergent, and this is more true for a well-figured speculum than for an object-glass.

Recently, in looking over a translation of Foucault's *mémoire* on "The Construction of Silvered Glass Specula," I was struck by his statement that he always saw "traces of the rings," and I wrote to M. Henry, who, I believe, follows Foucault's methods almost entirely, inquiring what his experience was. M. Henry kindly informs me that not only does he always see rings with his reflectors, but that they are, in fact, easier to see than with a refractor. In his article on Light I find that Sir J. Herschel states that the rings surrounding star images were discovered by Sir W. Herschel, but he says that they are less easily seen than with a refractor.

I have since calculated the places and brilliancy of the rings to be seen in a telescope with an obstructing disc one-third of the diameter of the aperture, centrally placed, and the result has somewhat surprised me.

Calling e the aperture of the telescope in English inches and s the angular diameter of the ring in seconds, Sir George Airy gives for an open aperture the following values, the unit of brilliancy being the centre of the images:—

es	2·76	3·70	5·16	6·09
Brilliancy	0	$\frac{1}{57}$	0	$\frac{1}{240}$

With one-third stopped centrally as above, which would nearly represent a reflector giving a field of 2° diameter, I find—

es	2·47	3·54	5·44	6·22
Brilliancy	0	$\frac{1}{18}$	0	$\frac{1}{712}$

It would follow that while the central image is smaller and also the first dark ring, the first bright ring would be far more conspicuous than in a refractor, both by its width and brilliancy, compared with the central image.

The place of the third dark ring would be very little inside the corresponding place in a refractor, and so would that of the

third bright ring, which, too, would be less brilliant than in a refractor.

It would require a good deal of labour in interpolating to get the diameters and brilliancy of the rings in a reflector where the small speculum is, as usual, only large enough to show a central object, or about one-ninth of that of the speculum, but it is evident that these would be intermediate between the two sets of values above given, and that there can be no theoretical reason why rings should be absent if carefully looked for under suitable circumstances, provided the figure is good.

I would add that I believe that the great diameter of the images of large stars on photographs will be explained, at all events in part, by the fact that the visible image is by no means all the acting light. If a plate be exposed so as to show stars of the 14th magnitude on the Paris scale, then we shall have sensible impressions made by light whose intensity is $\frac{1}{2 \cdot 5^{13}}$ of that of a 1st magnitude star. Roughly, we may call this $\frac{1}{149000}$ of the light, the distance from the centre of the image at which this fails is far beyond the powers of the integral table given in Sir G. Airy's little book, and I doubt if it could be determined with any accuracy, for at so great a distance the spectra would overlap, and it would be necessary to estimate the total effect of range of those colours which are impressed on the plate. Manifestly, however, the photographic image would be very large, though it does not seem possible it can fill the great space we sometimes see.

Of course light diffused within the photographic film would add its effects to those of incident lights.

P.S.—In a more recent communication M. Henry tells me that they some time ago tried specula up to 50 cm. (nearly 20 inches) with various sized patches, and under favourable circumstances found just such a brilliant ring as I have described.

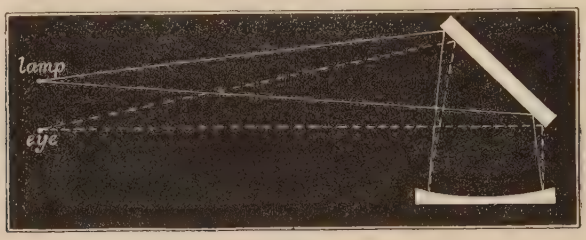
Note on Testing Polished Flat Surfaces.

By A. A. Common, F.R.S.

The following method of testing flat surfaces has some advantages over the methods generally employed, and is particularly useful in enabling the errors to be localised exactly. It is an extension of Foucault's method of testing concave surfaces, and consists in putting on the flat surface to be tested, in the cone of rays coming from a concave surface in the process of testing by Foucault's method, and thus finding the effect of the reflection on the course of the rays.

The concave mirror should strictly be quite spherical and, of course, somewhat larger than the plane surface to be tested, but an ordinary speculum will do almost as well; any errors that

the concave may have can be separated from the errors of the flat by rotating the one or the other and so taken account of.



The diagram given shows at once the arrangement, from which it will be seen that in this case the plane mirror receives the light from the lamps and from the mirror also, so that any error of the plane mirror would be doubled before reaching the eye.

In order to use this plan the method of testing concave surfaces described by Foucault must be thoroughly understood, as the one is only an extension of the other, and the pinhole, the straight line or system of squares, and the screen are to be used exactly as testing a concave mirror, but the whole of the testing can be done at the centre of curvature, and if a strictly spherical mirror be used the test can be made almost a rigid one.

Notes on the Solar Surface of 1887. By S. J. Perry, D.Sc., F.R.S.

Having just completed the measurement of the Sun's spot-area observed at Stonyhurst in 1887, I thought that some of the results might fitly be brought at once before the Society. The number of days in each month in which drawings were obtained was respectively 11, 18, 24, 22, 22, 28, 30, 25, 21, 23, 17, and 18, making a total of 259 days in the course of the twelve months.

When the areas had been reduced to millionths of the solar hemisphere and represented graphically, the first point that struck the eye was the prolongation of the minimum period during the first four months of the year, with its sudden cessation at the opening of May. We have thus already in this eleven-year period two minima, one lasting from September 22 to December 8 of 1886, or for two months and a half, and the other extending over the first third of 1887, more than twice as many days without spots being noted in the second period than in the first. But if we include both these periods in the same minimum, by neglecting the interruption at the close of 1886, then the whole minimum period includes 222 days, and the date of the minimum may be given approximately as January 10, 1887. In thus speaking of the minimum I do not wish it to be inferred

that the absolute minimum of the eleven-year period was reached on January 10, 1887. It would, of course, be premature to venture upon such an assertion, as we may not unreasonably look forward to even longer periods of solar inactivity during the years 1888 and 1889 than that which marked the end of 1886 and the beginning of 1887.

From May to August of the year that has just expired there was a considerable wave of disturbance corresponding to each rotation of the Sun, and these differed little in extent, although they were by no means periodic returns of the same groups to the visible hemisphere. For most of the larger spots and groups of spots have this year lasted but for a short time; one group only—namely, that which was first observed on January 27—having lasted for part of three revolutions. This group was finally observed as three small dots on March 22, but the faculæ of the group were still a conspicuous object during the next rotation. On seven days only was the Sun observed to be free from spots between May 1 and August 24, but from this date until November 30 the solar surface was more quiet, and thirty-five days are recorded as spotless. During the last month the spotted area has been larger than in any month since May 1886, December 15 being the date of the recent secondary maximum. The group visible from July 22 to the 30th was a typical case of the formation of a spot, the slight dot surrounded by a few faculæ being the first indication of the coming disturbance.

I should like for a moment to call attention to the secondary maximum that occurred in 1886, as there exists a marked difference between the results published by Wolf and by Tacchini; most of the results given by the former pointing to the beginning of March, and the latter giving April 1 as the date of the maximum. The Stonyhurst curve shows three maxima in 1886 in the following order as regards magnitude: March 8, May 2, and April 2, the spot area in millionths of the hemisphere being respectively 2,459, 2,274, and 1,575. As observations were very frequent at all these dates, and the results of consecutive days hold well together, I can scarcely believe that the state of the sky will suffice to account for such great discrepancies as would have to be admitted in order to accept the date of Prof. Tacchini.

Another point of some interest is the behaviour of the veiled spots during the period of minimum. These spots have for convenience of record been divided into three classes. The first class comprises those misty patches, large in extent, but of very short duration, which give an appearance of bad definition to whole regions of the solar surface. These, which were frequent about the time of maximum, have scarcely been seen at all this year. The second class, consisting of penumbral dots, which increase in size and then coalesce with other similar spots in their immediate neighbourhood, the total duration of any single spot never much exceeding three minutes, have been as frequent and as easily seen this year as they ever were before, but the

changes they have undergone during their short existence have not been so extended lately as in previous years. The third class of veiled spots, which differ from the two other classes in being confined to the spot zones, in their duration extending sometimes to several days, and in their close resemblance to minute patches of penumbra, have been observed this year rather less often than in 1883 and 1884. These faint objects have been examined both on the projected image and directly by aid of a solar prism and a Dawes eyepiece, and it is invariably found not only that the observation is far more easy, but more perfect in every way when the Sun is viewed by projection.

On October 28, at 9^h 5^m, a few faculæ attached to a group of faint spots became on a sudden intensely bright, and faded again as quickly as they had shone out.* During this appearance no other change of any importance occurred in the spots themselves or in their neighbourhood. Within three minutes both the faculæ and the spots had entirely disappeared. I may mention in conclusion that, although there have been this year many days without true spots, the Sun's surface has but rarely been entirely free from faculæ, which, however, were sometimes very faint.

Nebula in Andromeda and Nova, 1885. By T. W. Backhouse.

I. Magnitude of Nova.

The few observations I took of *Nova*, 1885, quite confirm the remark of Dr. Copeland in his paper in *Monthly Notices*, xlvii. p. 55, that lower powers showed it brighter than higher ones. The comparison stars and their magnitudes, as given in the *Durchmusterung*, as well as the adopted magnitudes based on these from estimates, are shown in the following table :—

No. in D.M.	Mag. in D.M.	Magnitude adopted.
40°, 158	7·5	7·25
39, 167	7·1	7·46
39, 166	8·5	8·69
41, 149	9·1	8·91
40, 145	9·0	9·02

The resulting magnitude of *Nova* with the different powers, 9 being the finder of telescope, and the other figures the approximate powers used on a $4\frac{1}{4}$-inch refractor, is as follows :—

* The Stonyhurst Magnetograms do not show any trace of this solar disturbance.

Power used.	1885 Sept. 3 $10\frac{1}{2}^h$.	Sept. 5 $10\frac{1}{2}^h$.	Sept. 9 11^h.	Sept. 16 11^h.	Sept. 24 11^h.	Oct. 1. 11^h.
9		7·5				
2-in. refractor	7·5					
38			7·9	8·4	9·0	
76		8·3			9·2	9·0
143			8·7			9·4

The star had so far declined in brightness as to be described as *very faint* with powers 76 and 143 on October 27; *quite faint* with power 76 on November 4.

II. Brightness of Nebula.

Estimates of the total light of the nebula itself were made, the comparison stars used being σ, ν, θ and ρ *Andromedæ*, whose magnitudes are modified from those of the *Harvard Photometry* according to their average positions in the sequences observed, thus:—

	H.P.	Adopted.
σ Andromedæ	4·65	4·50
ν ,,	4·42	4·57
θ ,,	4·30	4·82
ρ ,,	5·27	5·27

	Mag. of Nebula.
1885, Sept. 3	4·81
9	4·84
Oct. 1	4·91
1887, Oct. 21	4·70
Nov. 14	5·01
15	4·73
Dec. 4	4·81

The discordances of the results are no larger than might be expected, the comparison of a large area of light, like the nebula, with the stars not being very easy. These observations, therefore, do not show any appreciable increase of the brightness of the nebula arising from the presence of the new star, compared with its present light; the stellar nucleus from its faintness was, indeed, not likely to add perceptibly to the total light.

III. The Spectrum.

I made the following notes on the spectrum of the new star:—

1885, *September* 16.—Its spectrum is partly continuous, but there is certainly interrupted light as well, which must be either

bright lines or short bright spaces between broad absorption bands; I believe the former. There are certainly two bright spots (lines appear as spots with the apparatus used), one probably in the green, much plainer than the other, which is half-way from it to the red end. I strongly suspect a third at an equal distance on the other side of the brightest. The general appearance of the whole spectrum of star and nebula is very much like that of an ordinary comet.

November 5.—There can be no doubt the spectrum of the new star is highly interrupted, and I have little doubt it contains more than one definite bright line. The brightest is about at the brightest part of the spectrum of the nebula, which is continuous as far as I can see, though there may be brighter bands in its centre, but this suspected appearance may only be caused by the star's spectrum.

1886, *February* 1.—I think the spectrum of the nucleus of the nebula is not simply continuous, but has two or three or more bright bands on it; this may, however, be only imagination.

1887, *December* 7.—The spectrum of the nebula is certainly mainly continuous, though I suspect a bright line in the brightest part as well as other very slight irregularities, but I cannot be sure of any of them.

December 10.—With a low power the spectrum mostly appears quite continuous, though I sometimes have a faint suspicion of a very feeble line or lines.

All the above observations were made with a Browning miniature spectroscope on a $4\frac{1}{4}$-inch refractor by Cooke; the following was made without any telescope, merely using one or two prisms of dense flint glass, both with and without spectacles in addition:—

1887, *December* 9.—The spectrum seems perfectly continuous, without the slightest sign of any lines, a great contrast to that of the Great Nebula in *Orion* which, viewed in this manner, consists of two conspicuous bright lines.

Sunderland: 1887, *December* 22.

The Chief Meteor Showers. By W. F. Denning.

I have derived from my observations during the last fifteen years the following mean places for the radiants of the leading showers. The positions are corrected for precession, and brought up to 1890:—

Name of Shower.	Duration.	Date of Max.	Radiant Point. α δ	Sun's Longitude.
Quadrantids	Dec. 28–Jan. 4.	Jan. 2	229°·8 + 52°·5	281°·6
Lyrids	April 16–22	April 20	269·7 + 32·5	31·3
η Aquarids	April 30–May 6	May 6	337·6 − 2·1	46·3
δ Aquarids	July 23–Aug. 25	July 28	339·4 − 11·6	125 6
Perseids	July 11–Aug. 22	Aug. 10	45·9 + 56·9	138·5
Orionids	Oct. 9–29	Oct. 18	92·1 + 15·5	205·9
Leonids	Nov. 9–17	Nov. 13	150·0 + 22·9	231·5
Andromedes	Nov. 25–30	Nov. 27	25·3 + 43·8	245·8
Geminids	Dec. 1–14	Dec. 10	108·1 + 32·6	259·5

Notes.

Quadrantids.—Heis was the first to determine this radiant accurately. It was subsequently observed by Masters and Prof. Herschel (1863–4). The radiant is circumpolar in this latitude, but low down during the greater part of the night, hence the display is usually seen to the best advantage on the morning of Jan. 2.

Lyrids.—Attention was first drawn to the April meteors by Herrick in the United States (*B. A. Report*, 1871, p. 42). The probable identity of this meteor orbit with Comet I., 1861, was pointed out by Galle and Weiss. The earlier observers of this stream placed the radiant too far N.E., and the assumed accordance was therefore considered doubtful. My recent observations prove that the radiant is identical with that computed for the comet of 1861, and it exhibits a displacement to the E., as observed on successive nights. Prof. Herschel gives the cometary radiant as 270°·5 + 32°, April 20, Corrigan, 270°·9 + 33°·5.

η Aquarids.—Further observations are urgently required of this stream. The radiant is only visible for a short time before sunrise. There is a considerable difference between my results and those secured by Col. Tupman, the discoverer of this system in 1870, whose observations place the radiant at $326\frac{1}{2} - 2\frac{1}{2}$ April 29–May 3. These May Aquarids are interesting from the fact that they present an orbital resemblance to Halley's Comet which makes a near approach to the earth on May 4, twelve days before reaching the descending node. (See *Monthly Notices*, xlvi. p. 396–8.)

δ Aquarids.—The meteoric epoch, July 26–30, was first pointed out by Quetelet many years ago. Biot also found, from the oldest Chinese observations, a general maximum between July 18 and 27 (Humboldt). Showers of Aquarids were remarked by Schmidt, Tupman (1870), and others, but it was not known until observations in 1878 by the writer that the Aquarids formed the special display of the epoch, and that there were many early Perseids visible at the same time.

Perseids.—Muschenbroeck, in his work on "Natural Philosophy," printed in 1762, mentions that he observed shooting stars to be more numerous in August than in the other months of the year. Quetelet, in 1835, was, however, the first to attribute a definite maximim to the 9th–10th. This stream is remarkable for its extended duration, and for the obvious displacement which occurs from night to night in the place of its radiant (see *Monthly Notices*, xlv. pp. 97–8). The period of visibility appears to cover the forty-three nights from July 11 to August 22 inclusive, and the radiant advances from 11° + 48° to 76° + 57°. This shower apparently varies but little in its annual richness. In the morning of August 11 it usually yields from sixty to eighty meteors per hour for one observer. The centre of radiation on August 10 agrees with the

radiant assigned to Comet III., 1862, viz. 43° + 57°·5 (Herschel), and 43°·8 + 57°·2 (Corrigan).

Orionids.—Profs. Schmidt and Herschel were the first to discover the Orionids as the most brilliant display of the October period, and accurately determined its radiant in 1863–4–5. Herrick recorded a shower at 99° + 26°, Oct. 20–26, 1839, and Zezioli in 1868 recorded many meteors which were ascribed to a radiant at 111° + 29°, but there is no doubt that the Orionids were observed in both these cases, though the radiant was badly assigned. There is a contemporary shower at 106° + 22°, close to δ *Geminorum*, which is liable to be confused with the Orionids, but the latter is by far the richest of the pair. The radiant of the Orionids shows no displacement like the Perseids.

Leonids.—Observed from the earliest times. Humboldt and Bonpland saw it well on the night of November 11–12, 1799, and the phenomenon at its magnificent return on November 12, 1833, was ably discussed by Olmsted. It furnished a splendid shower in 1866, November 13, and many meteors were seen at the few subsequent returns. During the last fifteen years the displays have been extremely meagre. There is no doubt, however, that the meteors form a complete ellipse, for the earth encounters a few of the particles at every passage through the node. But the meteors are nearly all massed in the neighbourhood of their parent, Comet I. 1866, which gives a radiant at 150°·5 + 23°·5, November 13 (Herschel), and 150°·4 + 22°·8 (Corrigan). It is supposed that there are minor groups of meteors pursuing the same orbit; if so we may have a revival of this display in 1888, for "on the night of November 12, 1822, shooting stars mingled with balls of fire were seen in vast numbers at Potsdam by Klöden" (Lardner's *Museum*).

Andromedes.—Observed by Brandes, at Hamburg, December 7, 1798. It also recurred in 1838; the very brilliant showers of November 27, 1872 and 1885, are still fresh in the memory. It is uncertain whether this group forms an unbroken stream; if so, the regions far removed from the comet must be extremely attenuated. Some of the meteors were seen in 1877 and 1879. The radiant is diffuse to the extent of 7° or 10°. The cometary radiant is at 23°·4 + 43°·4 (Weiss), and 24° + 43°·2 * (Corrigan), which is very close to the meteoric centre. Returns of the shower should be looked for in 1892 and 1898.

Geminids.—Mr. Greg first called attention to the importance of this shower. It was well observed by Prof. Herschel in 1861–3–4, and some later years.

Bristol: 1887, *December.*

Heights of Fireballs and Shooting Stars. By W. F. Denning.

While occasionally engaged during the past year in computing meteor heights, I was led to compare the relative elevations of fireballs and ordinary shooting stars. The former before extinction appear to penetrate much lower in the air than the latter. From the real paths of the fireballs and smaller meteors seen by myself and other members of the Liverpool Astronomical Society at the end of 1886 and during 1887, it appears that the height of fireballs at disappearance is only about one-half that of shooting stars, the figures being 25 and 54 miles respectively. But these values are based on only 20 observations, and are, therefore, far from being conclusive. They are, however, amply

* These positions by Mr. Corrigan are taken from the *Sidereal Messenger*, May 1886.

confirmed by numerous records contained in the *Luminous Meteor Reports of the British Association*, the *Monthly Notices*, Heis's *Resultate der in den 43 Jahren 1833–1875 angestellten Sternschnuppen-Beobachtungen*, and other publications.

The mean heights, in British statute miles, of the best observed and most brilliant fireballs of the last twenty years or so, as computed by Prof. Herschel, Col. Tupman, and many others, and described in consecutive volumes of the *B. A. Reports*, *Monthly Notices*, &c., are as follow :—

	Height at beginning.	Height at ending.
80 fireballs, 1865–1887	69·2 miles	30·2 miles

Let us compare with these figures the mean heights of meteors (nearly all shooting stars of the 1st mag., or fainter) which I have derived from a collection of the results given by several different authorities :—

	No. of Meteors.	Height at beginning.	Height at ending.
E. Heis, *Resultate, &c.*	271	76·9 miles	50·1 miles
A. S. Herschel, *B. A. Reports*	86	79·5 „	53·3 „
T. H. Waller, *B. A. Report*, 1874	48	81·4 „	52·4 „
W. F. Denning, shooting stars seen in 1887	13	80·0 „	54·2 „

The average height of nearly all the meteors seen up to the end of 1862 (*B. A. Report*, 1863, p. 328) was—

At beginning.	At ending.
70·05 miles	54·22 miles.

These, however, included a proportion of fireballs. The mean heights deduced from the calculations of Heis, Herschel, and Waller, given in the above summary, are 79·3 and 51·9 miles, but a few fireballs were interspersed amongst these observations (though the great bulk of them consists of ordinary shooting stars), hence the values are perhaps slightly below the elevations that would be derived from the smaller meteors alone. A careful discussion of the various records gives the following mean relative heights :—

	At beginning.	At ending.	At mid-course.
Fireballs	69 miles	30 miles	49½ miles
Shooting stars	80 „	54 „	67 „

It appears from this that before attaining a visible degree of incandescence fireballs are usually eleven miles lower in the atmosphere than small meteors, and that upon final disruption they are twenty-four miles nearer the earth than the fainter class. The heights at mid-course differ by nearly eighteen

miles. It is also extremely probable that telescopic meteors are at yet greater elevations than the brighter forms of these bodies visible to the naked eye.

Bristol: 1887, *December.*

On Invisible Stars of Perceptible Actinic Power.

By Dr. R. de Kövesligethy.

(*Communicated by the Astronomer-Royal.*)

With reference to his well-known photographs of the small star in the annular nebula in *Lyra*, M. von Gothard was so kind as to call my attention to the possibility of a theoretical treatment of the question as to the existence of invisible stars of perceptible actinic power. The question may be generally resolved without the aid of any explicit law of emission. As I think the results may be of some importance as bearing upon the proposed photographic work shortly to be undertaken, I may be allowed to briefly point them out.

I exclude all stars of *merely* homogeneous ultra-violet light, not only because these cases may be very rare, but chiefly because the invisibility of such a star would be of no further account. I select rather stars of well-developed continuous spectra. Then, to speak briefly, I consider two methods of photometric observations as *different* when they select out of the spectrum a group of rays between *different* limits of wave-length. Thus eye observations and photographs of stars are regarded as different, the former limiting the star's spectrum between the Fraunhofer lines H and A, and the latter between about P and *b*. The influence of different sensibility of the two methods may be omitted, for it does not alter at all the following theoretical theses:—

(1) For two proposed methods of observation there exists at least one substance giving a continuous spectrum such that the total intensity of the light between defined limits is the same by both methods, or conversely.

(2) For any substance giving a continuous spectrum there are at least two methods of observation for which the intensity of the light within defined limits has the same value.

The theorem is evidently demonstrated if I could prove that the emission function contains at least two parameters not simultaneously eliminable.

Let I be the intensity of the ray of wave-length λ, θ the absolute temperature, $z_1, z_2 \ldots z_n$ certain quantities depending

partially or totally upon the temperature and substantial qualities. Then generally we have

$$I = f(\lambda, \theta, z_1, z_2 \ldots z^n).$$

That the number of parameters is at least two, which are not simultaneously eliminable, i.e. are not replaceable in the above equation by a single parameter, θ by virtue of a relation

$$\theta = \phi(\theta, z_1, z_2 \ldots z_n)$$

may be proved as follows.

According to the law of Clausius (Ueber die Concentration von Wärme u. Lichtstralen, "Pogg. Ann." cxxi. pag. i) the emission of absolutely opaque bodies in different media is proportional to the square of the refractive index, and as absorption proves independent of the surrounding medium we may say the same for any emission at all. If there were now but one parameter in the emission function, or if, when more, they were simultaneously eliminable, we should have the equation

$$n^2 f(\lambda, \theta) = f\left(\frac{\lambda}{n}, \theta\right),$$

which we could differentiate to θ, to obtain the law for a body physically similar, and eliminate θ from the two equations. The result would be

$$F(\lambda, n) = 0,$$

i.e. the equation of relative dispersion of the two media *independent* of substantial qualities. As this equation is absurd the supposition must be false; there are at least two independent parameters in the emission function.

Now let λ_1 and λ_2, λ^1 and λ^2 be the limiting wave-lengths between which two different methods of photometric observation give a continuous spectrum with the intensities L_1 and L^1, which may be quite independent of each other; then we have the following pair of simultaneous equations:

$$\int_{\lambda_1}^{\lambda_2} f(\lambda, \theta, z_1, z_2 \ldots z_n) d\lambda = L_1$$

$$\int_{\lambda^1}^{\lambda^2} f(\lambda, \theta, z_1, z_2 \ldots z_n) d\lambda = L^1$$

a solution of which, according to the demonstrated theorem, can always be found, since the members on the left contain at least two arbitrary parameters. The only conditions to which L_1 and L^1 are subject, are

$$\int_0^\infty f(\lambda, \theta, z_1, z_2 \ldots z_n) d\lambda > L_1, L^1 > 0.$$

When L_1 is smaller than the smallest perceivable intensity for

eye observation, L^1 greater than the least sensibility of photographic plates, we have M. von Gothard's case with the *Lyra* star; and since the possibility of the existence of such stars may be also proved theoretically, M. von Gothard's opinion that there might be found still more of these interesting objects may easily be verified during the general photographic survey of the heavens.

Budapest: January 12, 1888.
Meteorologische Centralanstalt.

Spectroscopic Results for the Motions of Stars in the Line of Sight, obtained at the Royal Observatory, Greenwich, in the year 1887. No. XI.

(*Communicated by the Astronomer Royal.*)

The results here given are in continuation of those printed in the *Monthly Notices*, vol. xxxvi. p. 318, vol. xxxvii. p. 32, vol. xxxviii. p. 493, vol. xli. p. 109, vol. xlii. p. 230, vol. xliii. p. 81, vol. xliv. p. 89, vol. xlv. p. 330, vol. xlvi. p. 126, and vol. xlvii. p. 101. The observations were made with the "half-prism" spectroscope, one "half-prism" with a dispersion of about $18\frac{1}{2}°$ from A to H being used throughout. A magnifying power of 14 was employed.

The cylindrical lens has always been used in front of the slit as in the observations made previously to 1881 and since. The observations of the Moon and of the sky have been made as a check on the general accuracy of the results.

The day specified in the first column is the civil day, and the hour is that of Greenwich civil time, commencing at Greenwich mean midnight, and reckoning from 0 to 24 hours.

The observations were made by Mr. Maunder throughout.

Motions of Stars in the Line of Sight in Miles per Second, observed with the Half-prism Spectroscope.

(+ denotes Recession; − Approach.)

Date. 1887.	h	No. of Meas.	Line.	Earth's Motion in miles per sec.	Concluded Motion of Star. Meas.	Concluded Motion of Star. Estimd.	Remarks.
				α Andromedæ.			
Sept. 1	0	2	F	− 9·2	−23·0	−26·0	Spectrum fairly steady.
Oct. 14	23	2	F	+ 2·5	− 5·9	− 7·1	Spectrum steady but rather faint.
19	21	2	F	+ 3·9	−26·1	−26·8	Definition fair.
21	22	4	F	+ 4·5	−24·2	−25·1	Spectrum fairly steady.
				β Cassiopeiæ.			
Oct. 19	22	2	F	− 1·5	+ 7·9	+ 7·6	Measures very rough.

Date. 1887.	h	No. of Meas	Line.	Earth's Motion in miles per sec.	Concluded Motion of Star. Meas.	Estimd.	Remarks.
				γ Pegasi.			
Sept. 1	0	4	F	− 8·7	−22·7	−23·2	Definition fair.
Oct. 14	23	2	F	+ 4·3	−25·9	−27·2	Measures made with great difficulty.
19	21	2	F	+ 5·7	−20·6	−21·0	Spectrum faint but steady.
				α Cassiopeiæ.			
Oct. 19	23	2	F	− 2·2	+13·9	+11·3	Observations made with great difficulty.
Nov. 1	0	2	b_1	+ 0·5	+58·8	+55·7	Definition fair.
				β Ceti.			
Oct. 28	23	2	b_1	+ 9·8	−67·0	−66·4	Spectrum faint and tremulous.
				γ Cassiopeiæ.			
Feb. 16	20	6	F	+12·0	+ 1·7	− 1·9	Star-line seen with difficulty. Measures rough.
Oct. 19	23	2	F	− 3·4	−17·1	−21·0	Star-line faint and broader and more diffused than usual.
				β Andromedæ.			
Oct. 28	23	2	b_1	+ 1·9	+31·7	+26·4	Spectrum bright but tremulous.
Nov. 1	0	2	b_1	+ 2·8	+26·7	+27·9	Definition fair.
				β Arietis.			
Oct. 21	22	2	F	−1·4	+48·8	+51·7	Definition fair.
				γ Andromedæ.			
Feb. 16	20	2	F	+16·1	−13·4	−12·8	Star-line faint.
Nov. 1	0	2	b_1	− 1·2	−19·8	−19·2	Star-line faint.
				α Arietis.			
Oct. 15	0	2	F	− 4·7	− 0·5	− 4·4	Spectrum and star-line faint.
21	22	4	F	− 2·6	+20·0	+25·5	Measures very rough.
28	23	4	b_1	− 0·3	+ 2·2	+ 5·0	Spectrum bright but tremulous.
				α Ceti.			
Oct. 28	23	4	b_1	− 2·4	+ 0·9	+ 2·4	It seems clear that the edge of the dark fluted band in this star is not the b_4 line. Assuming the observations of the b_1 line to be correct, the wave-length of the edge of the band, corrected for motion of earth and star, will be $\lambda = 5162{\cdot}63$, Ångström's value, 5166·88, for b_4 being assumed.
29	0	2	b_4	− 2·4	−137·1	−168·0	

Date. 1887.	h	No. of Meas.	Line.	Earth's Motion in miles per sec.	Concluded Motion of Star. Meas.	Estimd.	Remarks.
				β Persei.			
Jan. 26	22	4	F	+16·6	−90·0	−93·7	Definition bad.
28	20	4	F	+16·8	−16·5	−13·0	Definition poor.
31	20	5	F	+17·0	−18·4	−17·0	Definition bad.
Feb. 2	23	4	F	+17·1	−108·6	−105·2	Definition poor.
15	23	6	F	+17·4	−51·0	−49·0	Definition poor.
16	20	6	F	+17·4	−44·0	−40·9	Definition poor.
Oct. 20	0	4	F	− 8·1	−51·4	−52·8	Definition fair.
21	22	4	F	− 7·6	−81·3	−63·2	Definition good.
24	23	4	F	− 6·8	−38·7	−25·7	Definition fair.
				α Persei.			
Feb. 16	20	4	F	+16·3	−12·4	−11·3	Star-line of Procyon type.
Oct. 20	0	2	F	− 9·0	−26·9	−27·6	Definition fair.
21	23	2	F	− 8·6	−55·5	−53·1	Definition variable.
24	23	2	F	− 7·9	−42·4	−39·9	Definition fair.
				Aldebaran.			
Jan. 28	21	2	F	+16·4	+20·8	+29·3	Definition poor.
Feb. 16	21	2	F	+18·4	+24·9	+29·1	Definition fair.
Oct. 15	1	2	F	−13·5	+47·5	+47·1	Star-line seen with difficulty.
20	1	3	F	−12·4	+47·7	+49·3	Definition poor.
22	1	4	F	−11·9	+43·4	+49·6	Definition poor.
25	0	2	F	−11·1	+60·8	+54·6	Definition poor.
29	0	4	b_1	−10·1	+42·2	+45·7	Definition poor.
				Capella.			
Jan. 26	22	4	F	+12·6	+ 3·8	+ 8·1	Definition fair.
Feb. 16	0	2	F	+15·9	+18·5	+20·3	Definition poor.
Oct. 22	0	4	F	−13·5	+52·3	+52·7	Definition good.
25	0	4	F	−13·0	+38·4	+41·9	Star-line seen well occasionally.
29	1	4	b_1	−12·1	+52·7	+60·3	Star-line seen with difficulty.
				Rigel.			
Jan. 27	0	2	F	+12·7	+14·5	+18·9	Star-line very faint.
31	21	2	F	+13·5	+23·9	+10·8	Definition fair.
Feb. 3	0	2	F	+13·8	+13·5	+12·7	Measures rough.
12	22	2	F	+15·0	+ 1·0	+ 1·7	Definition poor.
16	21	2	F	+15·4	− 5·0	− 0·9	Definition poor.

Date. 1887.	h	No. of Meas.	Line.	Earth's Motion in miles per sec.	Concluded Motion of Star. Meas.	Estimd.	Remarks.
Oct. 20	1	2	F	−12·0	+32·4	+36·4	Definition poor.
22	0	6	F	−11·6	+28·7	+28·8	Spectrum bright but tremulous.
25	0	2	F	−11·1	+45·7	+37·2	Definition good.
				γ Orionis.			
Jan. 31	22	2	F	+14·4	−23·7	−21·7	Definition fair.
Feb. 12	22	2	F	+16·3	+26·2	+26·0	Definition fair.
16	22	4	F	+16·8	−12·6	−12·9	Definition fair.
Oct. 22	0	2	F	−13·8	+ 8·7	+ 9·3	Definition good.
25	1	4	F	−13·3	+16·5	+17·6	Spectrum bright but tremulous.
				β Tauri.			
Jan. 31	22	2	F	+14·6	−24·5	−21·9	Cloud passing.
Feb. 16	22	2	F	+17·2	−10·0	−10·5	Definition good.
Oct. 22	0	4	F	−14·7	−19·6	−12·3	Definition fair.
25	1	4	F	−14·1	− 0·6	− 5·5	Definition fair.
				δ Orionis.			
Feb. 16	21	4	F	+15·8	+11·4	+12·8	Definition poor.
Oct. 25	1	4	F	−13·0	+ 4·7	+10·9	Definition fair.
				ε Orionis.			
Feb. 16	21	2	F	+15·6	+16·8	+18·0	Definition fair.
Oct. 25	1	2	F	−13·1	+34·5	+34·8	Definition fair.
				ζ Orionis.			
Feb. 16	22	4	F	+15·4	−23·6	−20·1	Definition fair.
Oct. 25	1	4	F	−13·2	+11·7	+14·3	Definition fair.
				κ Orionis.			
Feb. 16	22	2	F	+14·1	−28·4	−25·3	Star-line faint.
				α Orionis.			
Oct. 29	1	2	b_1	−14·1	+69·3	+77·0	Spectrum bright but tremulous.
29	1	2	b_4	−14·1	+77·2	+76·0	Star-lines held with difficulty.
				β Aurigæ.			
Oct. 22	0	2	F	−15·0	+41·3	+41·7	Definition fair.
25	0	2	F	−14·5	+32·4	+33·4	Definition good.

Date, 1887.		No. of Meas.	Line.	Earth's Motion in miles per sec.	Concluded Motion of Star. Meas.	Estimd.	Remarks.
				γ Geminorum.			
Feb. 16	h 22	2	F	+14·4	−74·7	−64·8	Spectrum bright and steady.
				Sirius.			
Jan. 27	0	2	F	+ 6·0	−25·8	−27·0	Definition bad.
Feb. 3	0	6	F	+ 7·6	+12·7	+12·4	Definition fair.
12	21	4	F	+ 9·6	−13·0	−11·3	Spectrum very tremulous.
16	23	6	F	+10·3	− 6·8	− 7·5	Measures very rough.
Oct. 25	2	6	F	−13·6	+36·2	+34·4	Spectrum very tremulous.
				Castor.			
eb. 3	1	2	F	+ 8·0	−35·9	−36·2	Definition fair.
16	0	4	F	+11·5	−17·7	−15·1	Definition poor.
				Procyon.			
Feb. 3	1	2	F	+ 6·2	+20·2	+20·2	Definition good.
16	23	4	F	+10·0	−10·7	− 7·5	Spectrum very tremulous and star-line faint.
Oct. 29	3	4	b_1	−17·6	+54·0	+58·5	Star-line very faint indeed.
				Pollux.			
Feb. 16	1	2	F	+10·8	−44·4	−38·7	Definition poor.
Oct. 29	2	4	b_1	−18·0	−53·5	−51·2	Definition poor.
				Arcturus.			
July 4	23	2	F	+15·0	−43·3	−45·1	Definition poor.
11	23	2	F	+15·2	−43·3	−44·5	Definition poor.
				α Coronæ Borealis.			
July 11	23	2	F	+11·8	+20·7	+20·7	Spectrum tremulous.
Aug. 24	22	2	F	+12·1	−32·9	−30·8	Star-line seen with great difficulty; spectrum faint; measures rough.
				α Ophiuchi.			
July 12	0	2	F	+ 6·9	−21·5	−21·0	Definition poor.
Aug. 24	22	2	F	+13·7	−43·6	−34·4	Spectrum faint; definition bad.

Date. 1887.	h	No. of Meas.	Line.	Earth's Motion in miles per sec.	Concluded Motion of Star. Meas.	Estimd.	Remarks.
				Vega.			
July 12	0	2	F	+ 0·8	−38·1	−41·5	Definition fair.
Aug. 22	23	2	F	+ 6·1	−54·0	−55·5	Definition good.
24	23	2	F	+ 6·3	−63·1	−47·8	Definition bad.
31	23	4	F	+ 6·9	−51·3	−58·3	Definition poor.
Sept. 2	21	2	F	+ 7·1	−47·2	−49·3	Definition good.
Oct. 10	21	2	F	+ 8·7	−55·6	−57·5	Definition fair.
14	20	2	F	+ 8·7	−43·4	−41·4	Spectrum faint; slit narrow.
				γ Lyræ.			
Aug. 22	23	2	F	+ 6·5	−57·3	−51·8	Spectrum faint; measures rough.
				ζ Aquilæ.			
Aug. 23	0	2	F	+ 9·6	−27·1	−27·4	Spectrum faint; measures rough.
				δ Cygni.			
Oct. 10	22	4	F	+ 7·1	−25·1	−25·9	Spectrum faint; measures rough.
				Altair.			
July 12	1	2	F	− 2·9	−39·8	−40·4	Definition fair.
Aug. 23	0	2	F	+ 7·7	−53·3	−57·1	Star-line faint.
25	0	2	F	+ 8·1	−50·3	−39·2	Definition poor.
31	23	4	F	+ 9·7	−71·0	−63·5	Star-line very ill-defined.
Oct. 10	21	2	F	+15·7	−13·6	−15·7	Definition good.
14	21	2	F	+15·9	−16·9	−22·8	Definition fair.
				γ Cygni.			
Oct. 14	21	2	F	+ 8·5	−29·6	−35·2	Spectrum faint; definition fair.
31	21	4	b_1	+ 9·8	−20·3	−18·3	Definition bad; measures rough.
				α Cygni.			
Aug. 23	0	2	F	− 0·7	−43·1	−44 6	Definition good.
31	23	2	F	+ 0·7	−47·5	−47·1	Definition fair.
Oct. 14	21	2	F	+ 6·8	−39·0	−33·5	Spectrum faint but steady.
31	21	2	b_1	+ 8·4	−93·3	−80·8	Definition bad; measures rough.

Date. 1887.	h	No. of Meas.	Line.	Earth's Motion in miles per sec.	Concluded Motion of Star. Meas.	Estimd.	Remarks.
				ε Cygni.			
Oct. 14	21	2	F	+ 9·9	− 1·4	+ 1·5	Spectrum faint; measures rough.
31	22	4	b_1	+11·5	−11·8	−11·5	Definition bad; measures rough.
				α Cephei.			
Aug. 23	1	2	F	− 4·3	−47·5	−47·1	Definition fair.
Oct. 14	22	2	F	+ 1·2	−60·6	−58·3	Spectrum faint.
				ε Pegasi.			
Oct. 14	22	2	F	+13·3	+26·5	+32·4	Star-line faint, but sharp.
31	23	2	b_1	+16·0	+ 5·1	+ 4·4	Definition bad; measures rough.
				β Pegasi.			
Oct. 28	22	2	b_1	+ 9·6	−56 9	−51·5	Spectrum rather faint, but definition good.
28	22	4	b_4	+ 9·6	−56·6	−54·1	
31	23	2	b_1	+10·3	−20·7	−20·5	Spectrum faint and tremulous.
				α Pegasi.			
Sept. 1	0	4	F	− 4·0	−25·9	−29·8	Spectrum faint; measures rough.
Oct. 14	23	2	F	+ 8·5	− 5·6	− 4·0	Spectrum faint; sky clouding.
19	20	2	F	+ 9·8	−22·7	−23·5	Definition fair.
24	22	2	F	+11·1	−31·3	−32·8	Definition good.
				Great Nebula in Orion.			
Oct. 25	2	6	F	− 5·0	−12·4	− 7·4	Spectrum faint; measures rough.

Moon.

Date.	h	No. of Meas.	Line.	Motion Measured.	Remarks.
Jan. 31	19	5	F	+ 1·5	The coincidence of the two spectra appeared perfect.
Feb. 3	0	5	F	+ 1·6	
July 12	1	5	F	+ 0·0	
Sept. 1	0	5	F	+ 0·8	
Oct. 24	22	5	F	− 1·3	
28	23	5	b_1	− 1·3	
Nov. 1	1	5	b_1	− 1·0	

Sky.

Oct. 11	12	5	F	+ 5·3			Slit rather wide.
22	12	5	F	+ 1·9			The coincidence of the two spectra appeared perfect.

Observations of Occultations of Stars by the Moon, and Phenomena of Jupiter's Satellites, made at the Royal Observatory, Greenwich, in the year 1887.

(*Communicated by the Astronomer Royal.*)

Occultations of Stars by the Moon.

Day of Obs.	Phenomenon.		Telescope.	Power.	Moon's Limb.	Mean Solar Time of Observation. h m s	Observer.
1887, Jan. 5	Disapp.	*f* Tauri	Lassell Refl.	170	Dark	5 21 20·15	H. T
5	,,	*f* Tauri	Altaz	100	,,	5 21 19·88	T.
5	,,	*f* Tauri	N. Eq.	80	,,	5 21 20·22	C.
5	Reapp.	*f* Tauri	N. Eq.	80	Bright	6 24 33·88	C.
6	,,	θ^2 Tauri	Altaz.	100	,,	8 54 22·36	R. W.
6	,,	θ^1 Tauri	Altaz.	100	,,	9 2 18·86	R. W.
6 (*a*)	Disapp.	Aldebaran	E. Eq.	210	Dark	12 16 24·53	A. D.
6 (*b*)	,,	Aldebaran	Altaz.	100	,,	12 [illegible] 24·19	R. W.
12	Reapp.	45 Leonis	E. Eq.	140	,,	[illegible]1 5·64	A. D.
12	Disapp.	ρ Leonis	E. Eq.	140	Bright	[illegible]1 29 41·02	A. D.
12	Reapp.	ρ Leonis	E. Eq.	140	Dark	12 30 15 02	A. D.
28	Disapp.	4 Ceti	E. Eq.	140	,,	7 15 40·91	A. D.
28	,,	4 Ceti	Altaz.	100	,,	7 15 40·79	S. D.
28	,,	5 Ceti	E. Eq.	140	,,	7 42 3·78	A. D.
28	,,	5 Ceti	Altaz.	100	,,	7 42 4·38	S. D.
Feb. 2 (*c*)	,,	48 Tauri	E. Eq.	60	,,	13 14 16·33	L.
6	,,	3 Cancri	Altaz.	100	,,	9 17 15·72	H. T.
6	,,	3 Cancri	E. Eq.	210	,,	9 17 14 89	L.

Day of Obs.		Phenomenon.		Telescope.	Power.	Moon's Limb.	Mean Solar Time of Observation. h m s	Observer.
1887, Mar.	2	Disapp.	Aldebaran	E. Eq.	70	Dark	5 46 56·97	H. T.
	2 (*d*)	,,	Aldebaran	Altaz.	100	,,	5 46 56·75	T.
	2	,,	Aldebaran	Detached Tel. No. 2	65	,,	5 46 56·97	L.
	2 (*e*)	Reapp.	Aldebaran	Lassell finder	30	Bright	6 3 19·76	H. T.
	2 (*f*)	,,	Aldebaran	Altaz.	100	,,	6 3 19·63	T.
	2 (*g*)	,,	Aldebaran	E. Eq.	70	,,	6 3 18·09	L.
	13	,,	γ Libræ	E. Eq.	70	Dark	17 9 45·29	H. T.
	29 (*h*)	Disapp.	θ^1 Tauri	E. Eq.	140	,,	9 16 52·42	T.
	29 (*i*)	,,	θ^2 Tauri	E. Eq.	140	,,	9 25 33·49	T.
Apr.	7 (*k*)	,,	46 Virginis	E. Eq.	140	,,	9 22 24·16	L.
	14 (*l*)	Reapp.	57 Sagittarii	Altaz.	100	,,	16 9 29·40	A. D.
	30	Disapp	54 Cancri	E. Eq.	140	,,	9 35 44 48	H.
	30	,,	o^1 Cancri	E. Eq.	140	,,	12 24 39·84	H.
July	1 (*m*)	,,	η Libræ	E. Eq.	210	,,	9 23 5·00	C.
	1 (*n*)	,,	η Libræ	Altaz.	100	,,	9 23 4·65	L.
Aug.	8	Reapp.	29 Ceti	Altaz.	100	,,	16 5 8·16	L.
	31	Disapp.	45 Capricorni	Altaz.	100	,,	12 14 34·94	A. D.
Sept.	28	,,	42 Aquarii	E. Eq.	210	,,	10 13 9·18	A. D.
Oct.	12	,,	Regulus	E. Eq.	210	Bright	16 44 16·61	H. T.
	12 (*o*)	,,	Regulus	Altaz.	100	,,	16 44 16·66	L.
	12 (*p*)	Reapp.	Regulus	E. Eq.	210	Dark	17 50 38·99	H. T.
	12	,,	Regulus	Altaz.	100	,,	17 50 36·65	L.

Day of Obs.		Phenomenon.		Telescope.	Power.	Moon's Limb.	Mean Solar Time of Observation. h m s	Observer.
1887, Oct.	26	Disapp.	70 Aquarii	E. Eq.	210	Dark	7 49 48·82	C.
	28	„	Piazzi 0–60	Altaz.	100	„	11 31 35·43	H. T.
	28	„	Piazzi 0–60	E. Eq.	210	„	11 31 35 82	C.
	31 (*q*)	„	μ Ceti	Cooke Eq.	210	Bright	14 33 7 89	L.
	31 (*r*)	„	μ Ceti	Altaz.	100	„	14 32 55·76	H.
Nov.	6 (*s*)	Reapp.	*g* Geminorum	Altaz.	100	Dark	10 52 14·09	T.
Dec.	27	Disapp.	75 Tauri	Altaz.	100	„	6 26 32·34	B.

Notes.

(*a*) (*b*) Disappearance instantaneous.

(*c*) Observation not considered satisfactory; the counting of the clock-beats interfered with by noise.

(*d*) Sky very foggy. Disappearance instantaneous.

(*e*) No low-power eyepiece for the large telescope could be found, and as there was barely time for the accurate setting in position-angle required for a high power, the reappearance was observed in the finder, a small reflecting telescope of 4·4 inch aperture The reappearance did not seem to be instantaneous. Star appeared bright as compared with the surface of the Moon. Seemed to cling to the limb, and be divided by a projection on the limb, the northern portion of the star being fainter.

(*f*) Star appeared to run along the Moon's limb.

(*g*) Star appeared to run along the Moon's limb for about 19^s; for 5^s it had the appearance of shining from behind some obstacle, which seemed to split the image of the star into two. It did not appear to be quite clear of the Moon's limb till 32^s after the reappearance.

(*h*) Star appeared very faint before the disappearance.

(*i*) Star appeared very faint indeed before the disappearance.

(*k*) Slight haze round the Moon. The star appeared to be almost in contact with the rugged bright edge of the Moon at the disappearance.

(*l*) Star very faint when first seen.

(*m*) Cloudy, but observation considered satisfactory.

(*n*) Star faint; cloudy.

(*o*) Star appeared in contact with the Moon's limb 3^s before the actual disappearance.

(*p*) The star reappeared nearer to the edge of the field than was expected, and seems from L.'s observation (with which it was compared 1^m afterwards) not to have been seen at the first moment of reappearance.

(*q*) The star seemed to come in contact with a prominence on the Moon's limb, and slide down the incline about 3^s before the actual disappearance.

(*r*) Moon very bright; difficult to see the star just before its disappearance behind a roughness on the limb.

(*s*) Star very faint; sky thick.

Phenomena of Jupiter's Satellites.

Day of Obs.	Satellite.	Phenomenon.		Telescope.	Power.	Mean Solar Time of Observation. h m s	Mean Solar Time of N.A. h m s	Observer.
1887, April 3	II.	Ecl. D.	Began to fade	E. Eq.	210	10 51 13	10 54 12	A. D.
3	II.		Last seen	,,	,,	10 53 48		,,
8 (*a*)	III.	Occ. R.	Bisection	,,	,,	11 37 30	11 41	H. T.
8	III.		Last contact	,,	,,	11 40 30		,,
14	I.	Occ. R.	First seen	,,	,,	10 9 58		F.
14	I.		Bisection	,,	,,	10 13 13	10 15	,,
14	I.		Last contact	,,	,,	10 16 45		,,
19	II.	Tr. Ing.	First contact	,,	,,	11 2 46	11 6	L.
19	II.		Last contact	,,	,,	11 8 30		,,
20 (*b*)	I.	Tr. Ing.	First contact	,,	140	12 27 53		T.
20	I.		Bisection	,,	,,	12 30 22	12 30	,,
20	I.		Last contact	,,	,,	12 33 52		,,
May 5 (*c*)	II.	Occ. D.	First contact	,,	,,	9 47 42		A. D.
5	II.		Bisection	,,	,,	9 50 21	9 55	,,
5	II.		Last contact	,,	,,	9 54 6		,,

Day of Obs.	Satellite.	Phenomenon.		Telescope.	Power.	Mean Solar Time of Observation. h m s	Mean Solar Time of N.A. h m s	Observer.
1887, May 10 (*d*)	III.	Tr. Ing.	First contact	E. Eq.	210	12 44 9	12 47	L.
10	III.		Last contact	,,	,,	12 49 48		,,
14	I.	Occ. D.	Bisection	,,	,,	9 25 32	9 25	A. P.
14	I.		Last contact	,,	,,	9 28 2		,,
14	I.	Ecl. R.	First seen	,,	,,	12 7 19	12 7 16	,,
21 (*e*)	II.	Tr. Ing.	First contact	,,	,,	9 6 29	9 9	A. D.
21	II.		Bisection	,,	,,	9 9 13		,,
21	II.		Last contact	,,	,,	9 11 58		,,
21	III.	Ecl. R.	First seen	,,	,,	10 26 48	10 28 55	,,
21	III.		Full brightness	,,	,,	10 32 30		,,
21 (*f*)	III.		First seen	Altaz.	100	10 29 19		T.
21	I.	Occ. D.	First contact	E. Eq.	210	11 5 10	11 10	A. D.
21	I.		Bisection	,,	,,	11 7 54		,,
21	I.		Last seen	,,	,,	11 11 35		,,
21	II.	Tr. Egr.	First contact	,,	,,	11 38 19	11 42	,,
21	II.		Last contact	,,	,,	11 45 3		,,
June 13	II.	Occ. D.	Bisection	,,	,,	10 48 58	10 49	R. W.
13	II.		Last seen	,,	,,	10 50 49		,,

Day of Obs.	Satellite.	Phenomenon.		Telescope.	Power.	Mean Solar Time of Observation. h m s	Mean Solar Time of N.A. h m s	Observer.
1887, June 13	I.		First contact	E. Eq.	210	10 57 41		R. W.
13	I.		Bisection	,,	,,	11 0 7	11 0	,,
13	I.		Last seen	,,	,,	11 1 26		,,
22 (*g*)	III.	Tr. Ing.	First contact	,,	140	9 29 9	9 39	A. D.
22	III.		Last contact	,,	,,	9 41 46		,,
22	II.	Tr. Egr.	First contact	,,	,,	10 20 1		,,
22	II.		Bisection	,,	,,	10 24 2	10 21	,,
22	II.		Last contact	,,	,,	10 28 31		,,
22 (*h*)	I.	Ecl. R.	First seen	,,	,,	10 36 29	10 36 7	,,
22 (*i*)	I.		First seen	Altaz.	100	10 39 39		H.
July 3	III.	Ecl. R.	First seen	,,	,,	10 17 4	10 18 54	T.
7 (*k*)	I.	Tr. Egr.	First contact	,,	,,	10 44 31	10 31	,

Notes.

(*a*) Sky cloudy at time of first contact; last contact observed through passing clouds. (*b*) Sky hazy.
(*c*) *Jupiter* very ill-defined. The observations of first contact and bisection considered unsatisfactory.
(*d*) Sky hazy. Limb of *Jupiter* ill-defined. (*e*) Satellite very faint; sky thick.
(*f*) Satellite very faint. (*g*) *Jupiter's* limb badly defined.
(*h*) Time of full brightness could not be estimated on account of clouds; the time when first seen is considered accurate.
(*i*) Cloudy. (*k*) Satellite hardly visible; planet very low.

Observations of Phenomena of Jupiter's Satellites, at Windsor, New South Wales, in the year 1887. By J. Tebbutt.

Day of Observation.	Satellite.	Phenomena.	Phase.	Aperture of Telescope.	Mag. Power.	Windsor Mean Time of Phase. h m s	Correction to Nautical Almanac. m s
1887, Mar. 17	I.	Ecl. D.	Last seen	8-inch	170	10 25 59·4	+ 0 56·6
25	I.	Tr. Ingr.	Ext. contact	,,	,,	9 59 23·0	
25	I.	,,	Int. contact	,,	,,	10 3 52·3	
25	III.	Ecl. D.	Began to fade	,,	,,	10 59 57·9	
25	III.	,,	Last seen	,,	,,	11 8 28·5	+ 6 14·7
25	III.	Ecl. R.	First seen	,,	,,	12 50 58·9	− 1 24·9
25	III.	,,	Full brightness	,,	,,	12 59 53·0	
April 2	I.	Ecl. D.	Began to fade	$4\frac{1}{2}$-inch	130	8 38 53·9	
2	I.	,,	Last seen	,,	,,	8 40 53·1	+ 0 36·3
7	II.	,,	Began to fade	8-inch	170	10 13 39·5	
7	II.	,,	Last seen	,,	,,	10 16 21·0	+ 0 28·2
9	I.	,,	Began to fade	,,	,,	10 32 51·8	
9	I.	,,	Last seen	,,	,,	10 34 47·0	+ 0 56·2
10	I.	Tr. Ingr.	Ext. contact	$4\frac{1}{2}$-inch	130	7 56 16·5	
10	I.	,,	Int. contact	,,	,,	8 0 30·8	
10	I.	Tr. Egr.	Int. contact	8-inch	170	10 3 30·2	
10	I.	,,	Ext. contact	,,	,,	10 7 24·6	
23	II.	Tr. Ingr.	Ext. contact	,,	,,	10 13 4·2	

Day of Observation.	Satellite.	Phenomena.	Phase.	Aperture of Telescope.	Mag. Power.	Windsor Mean Time of Phase. h m s	Corrected to Nautical Almanac. m s
1887, Apr. 23	II.	Tr. Ingr.	Bisection	8-inch	170	10 16 33 7	
23	II.	,,	Int. contact	,,	,,	10 19 33·2	
25	II.	Ecl. R.	First seen	4½-inch	130	7 19 10·3	+ 2 14·5
30	III.	,,	First seen	8-inch	170	8 35 44·7	− 3 2·1
30	III.	,,	Full brightness	,,	,,	8 42 46·1	
May 3	I.	Tr. Ingr.	Ext. contact	,,	,,	7 35 46·2	
3	I.	,,	Bisection	,,	,,	7 37 35·9	
3	I.	,,	Int. contact	,,	,,	7 39 5·6	
7	III.	Occ. D.	First contact	,,	,,	9 19 9·5	
7	III.	,,	Last seen	,,	,,	9 35 6·9	
7	III.	Ecl. R.	First seen	,,	,,	12 33 7·2	− 3 24·6
7	III.	,,	Full brightness	,,	,,	12 46 35·0	
9	I.	Occ. D.	First contact	,	,,	12 9 11·9	
9	I.	,,	Bisection	,,	,,	12 11 11·5	
9	I.	,,	Last seen	,,	,,	12 13 1·2	
9	II.	Ecl. R.	First seen	,,	,,	12 30 29·8	+ 0 35·0
9	II.	,,	Full brightness	,,	,,	12 34 7 7	
10	I.	Tr. Ingr.	Ext. contact	,,	,,	9 20 40·4	
10	I.	,,	Int. contact	,,	,,	9 23 39 9	
11	I.	Ecl. R.	First seen	,,	230	9 13 35·1	− 0 0·7

Day of Observation.	Satellite.	Phenomena.	Phase.	Aperture of Telescope.	Mag. Power.	Windsor Mean Time of Phase h m s	Correction to Nautical Almanac. m s
1887, May 11	I.	Ecl. R.	Full brightness	8-inch	230	9 16 11·2	
25	III.	Tr. Egr.	Bisection	,,	138	7 11 40·6	
25	III.	,,	Ext. contact	,,	,,	7 19 9·4	
25	II.	Tr. Ingr.	Ext. contact	,,	230	8 23 48·6	
25	II.	,,	Bisection	,,	,,	8 24 58·4	
25	II.	,,	Int. contact	,,	,,	8 26 48·1	
25	I.	Occ. D.	First contact	,,	,,	10 7 11·4	
26	I.	Tr. Ingr.	Ext. contact	,,	138	7 17 39·1	
26	I.	,,	Int. contact	,,	,,	7 22 8·4	
June 3	I.	Ecl. R.	First seen	,,	230	9 24 37·4	− 0 6·4
3	I.	,,	Full brightness	,,	,,	9 27 12·9	
3	II.	,,	First seen	,,	,,	9 40 11·3	+ 0 23·5
3	II.	,,	Full brightness	,,	,,	9 43 10·3	
12	I.	,,	First seen	,,	,,	5 47 46·8	+ 0 3·0
12	I.	,,	Full brightness	,,	,,	5 50 50·3	
12	III.	Ecl. D.	Began to fade	,,	138	6 41 21·9	
12	III.	,,	Last seen	,,	,,	6 51 45·1	+ 5 47·3
12	III.	Ecl. R.	First seen	,,	,,	8 22 57·5	− 3 14·3
12	III.	,,	Full brightness	,,	,,	8 33 23·2	
18	I.	Tr. Ingr.	Ext. contact	,,	,,	7 10 38·9	

Day of Observation.	Satellite.	Phenomena.	Phase.	Aperture of Telescope.	Mag. Power.	Windsor Mean Time of Phase.	Correction to Nautical Almanac.
						h m s	m s
1887, June 18	I.	Tr. Ingr.	Bisection	8-inch	138	7 12 38·6	
18	I.	,,	Int. contact	,,	,,	7 15 8·2	
18	I.	Tr. Egr.	Int. contact	,,	,,	9 19 2·5	
18	I.	,,	Bisection	,,	,,	9 23 56·7	
18	I.	,,	Ext. contact	,,	,,	9 26 16·3	
19	III.	Occ. D.	First contact	,,	,,	5 58 20·7	
19	III.	,,	Bisection	,,	,,	6 3 34·8	
19	III.	,,	Last seen	,,	,,	6 6 49·3	
19	II.	Tr. Egr.	Int. contact	,,	,,	7 8 39·0	
19	II.	,,	Bisection	,,	,,	7 13 8·2	
19	II.	,,	Ext. contact	,,	,,	7 16 52·6	
19	I.	Ecl. R.	First seen	,,	,,	7 41 55·4	− 0 16·4
19	I.	,,	Full brightness	,,	,,	7 45 17·8	
19	III.	Occ. R.	First seen	,,	,,	7 58 30·6	
19	III.	,,	Last contact	,,	,,	8 5 29·5	
19	III.	Ecl. D.	Began to fade	,,	,,	10 40 33·6	
19	III.	,,	Last seen	,,	,,	10 52 0·7	+ 6 20·9
25	I.	Tr. Ingr.	Ext. contact	,,	,,	9 1 58 8	
25	I.	,,	Bisection	,,	,,	9 4 18·4	

Day of Observation.	Satellite.	Phenomena.	Phase.	Aperture of Telescope.	Mag. Power.	Windsor Mean Time of Phase.	Correction to Nautical Almanac.
						h m s	m s
1887, June 25	I.	Tr. Ingr.	Int. contact	8-inch	138	9 6 33·1	
26	II.	,,	Ext. contact	,,	,,	7 5 7·7	
26	II.	,,	Bisection	,,	,,	7 6 47·4	
26	II.	,,	Int. contact	,,	,,	7 9 2·0	
26	III.	Occ. D.	First contact	,,	,,	9 37 42·2	
July 14	III.	Tr. Ingr.	Ext. contact	,,	300	7 4 0·5	
14	III.	,,	Bisection	,,	,,	7 8 29·8	
14	III.	,,	Int. contact	,,	,,	7 15 13·6	
14	III.	Tr. Egr.	Bisection	,,	230	9 17 38·2	
14	III.	,,	Ext. contact	,,	,,	9 23 7·3	
18	I.	Tr. Ingr.	Ext. contact	,,	138	9 10 37·4	
18	I.	,,	Bisection	,,	,,	9 12 47·0	
18	I.	,,	Int. contact	,,	,,	9 15 21·6	
21	II.	Tr. Egr.	Bisection	,,	230	6 31 46·8	
21	II.	,,	Ext. contact	,,	,,	6 35 11·2	
25	III.	Ecl. D.	Began to fade	,,	,,	6 36 28·5	
25	III.	,,	Last seen	,,	,,	6 47 19·7	+ 6 1·9
25	III.	Ecl. R.	First seen	,,	,,	8 14 10·1	− 3 1·7
25	III.	,,	Full brightness	,,	,,	8 23 40·6	

Day of Observation.	Satellite.	Phenomena.	Phase.	Aperture of Telescope.	Mag. Power.	Windsor Mean Time of Phase.	Correction to Nautica Almanac.
						h m s	m
1887, July 27	I.	Tr. Egr.	Int. contact	8-inch	138	7 46 46·3	
27	I.	,,	Ext. contact	,,	,,	7 52 15·3	
28	I.	Ecl. R.	First seen	,,	,,	6 12 23·6	− 0 17·2
28	I.	,,	Full brightness	,,	,,	6 14 1·3	
28	II.	Tr. Ingr.	Ext. contact	,,	230	6 31 48·4	
28	II.	,,	Bisection	,,	,,	6 33 28·1	
28	II.	,,	Int. contact	,,	,,	6 35 27·8	
28	II.	Tr. Egr.	Int. contact	,,	138	9 4 3·0	
28	II.	,,	Bisection	,,	,,	9 7 32·4	
28	II.	,,	Ext. contact	,,	,,	9 11 16·8	
30	II.	Ecl. R.	First seen	,,	,,	6 37 40·8	+ 0 15·0
30	II.	,,	Full brightness	,,	,,	6 42 26·5	
Aug. 1	III.	Occ. R.	Last contact	,,	230	7 30 15·5	
3	I.	Tr. Ingr.	Ext. contact	,,	138	7 32 33·2	
3	I.	,,	Bisection	,,	,,	7 34 42·8	
3	I.	,,	Int. contact	,,	,,	7 37 12·4	
6	II.	Ecl. R.	First seen	4½-inch	120	9 15 11·5	+ 0 51·7
6	II.	,,	Full brightness	,,	,,	9 17 55·0	
Sept. 12	I.	,,	First seen	8-inch	230	6 38 15·0	− 0 4·8
12	I.	,,	Full brightness	,,	,,	6 40 59·5	

Remarks.

March 17.—Sky clear; slight boiling of the planet's limb.

March 25.—Sky clear. Bad definition and images unsteady at ingress. Definition somewhat improved during the eclipse. Satellite suspected at $12^h\ 50^m\ 31^s{\cdot}5$. Reappearance difficult to observe in consequence of the satellite's proximity to the limb.

April 2.—Clear sky and good definition. Good observation.

April 7.—A very thin cloud passed over at the critical time, but did not appear to dim the satellites. Excellent definition. Satellite suspected again at $10^h\ 16^m\ 38^s{\cdot}6$.

April 9.—Sky beautifully clear, but the Moon very bright and near the planet.

April 10.—Definition pretty good throughout.

April 23.—Definition pretty good, but images unsteady.

April 25.—Reappearance noted just as the planet was emerging from a cloud, and satellite then tolerably well seen.

April 30.—Planet very slightly dimmed by faint cloud when satellite first seen; satellite suspected a few seconds earlier. Reappearance very slow, and full brightness difficult to determine.

May 3.—Definition not good.

May 7.—Definition fairly good. Disappearance very gradual, owing to the inclination of the planet's limb. Sky beautifully clear at the reappearance, and the definition fairly good. Full Moon distant a few degrees from the planet. The recovery of the satellite's light was very gradual, and at greatest brightness it slightly surpassed satellite I. near it.

May 9.—Definition pretty good at the occultation, and better at the eclipse The observation of reappearance was rather late and the full brightness could not be well determined.

May 10.—Definition very bad.

May 11.—Steadiness and definition satisfactory. Satellite suspected at $9^h\ 13^m\ 26^s{\cdot}6$. Full brightness difficult to determine.

May 25.—Definition fair at ingress of III. Images steady and well defined at ingress of II. Planet faint and badly defined at occultation of I.

May 26.—Fair definition.

June 3.—Sky beautiful and the images steady and well defined. Planet a few degrees distant from the Moon.

June 12.—Beautifully clear, but the definition at the eclipse of I. was not good. Observation probably rather late. Images rather tremulous at disappearance of III. III. lost about half its light by $6^h\ 45^m\ 41^s{\cdot}2$, and was suspected at $6^h\ 52^m\ 0^s{\cdot}1$. Definition better at reappearance.

June 18.—Definition better at ingress than at egress; the internal contact at egress was probably observed too early.

June 19.—Total disappearance of III. in occultation; doubtful in consequence of a passing cloud. Planet and satellite faint at egress of II. Sky beautifully clear at reappearance of I., and images bright, steady, and well defined. Definition not so good at the last contact at reappearance of III. Sky still clear at disappearance of III. and images steady and well defined. Satellite glimpsed again at $10^h\ 52^m\ 26^s{\cdot}6$.

June 25.—Good definition.

June 26.—Sky clear and definition good at ingress of II. Clouds prevented further observation of III.

July 14.—Definition fairly good at the external but not so good at the internal contact at ingress. Planet faint and badly defined at egress.

July 18.—Definition good at the external contact, but bad at the other phases. Satellite IV., which was about in conjunction with the planet's centre, was remarkably dull and faint.

July 21.—Definition pretty good.

July 25.—Definition pretty good at both phases, but Moon near planet.

July 27.—Definition bad at internal but better at external contact.
July 28.—Sky beautifully clear. Definition fair at reappearance of I., but much disturbed during the other observations.
July 30.—Sky beautifully clear, and good definition.
Aug. 1.—Definition pretty good.
Aug. 3.—Fair definition.
Aug. 6.—Sky beautifully clear, and definition good; but satellite rather conspicuous when first seen.
Sept. 12.—Sky clear, and definition good; the twilight, however, had not quite disappeared.

Windsor, N.S. Wales:
1887, *November* 28.

Ephemeris of the Satellites of Mars, 1888. By A. Marth.

The values of the longitude of the node N and of the inclination J of the orbit of *Deimos*, in reference to the plane parallel to the Earth's equator, which have been employed in the following ephemeris are

$$N = 49^\circ\,549, \qquad J = 36^\circ{\cdot}029.$$

The assumed proportion of the mass of the Sun to that of *Mars* is

$$\odot = 3095000.$$

The orbital longitude of *Deimos*, reckoned from the node, is

$$u_2 = 145^\circ{\cdot}80 + 285^\circ{\cdot}1620\,(t - t_0),$$

the epoch t_0 being 1888, April, 12·0 Gr.

Phobos is assumed to move in the plane of the orbit of *Deimos*, and its longitude is taken to be

$$u_1 = 101^\circ{\cdot}16 + 1128^\circ{\cdot}8490\,(t - t_0),$$

its value being somewhat uncertain, as no observations of the satellite made during the last opposition have become known.

a, b, major and minor semi-axes of the apparent ellipses described by the satellites.

P, position-angle of the minor axes in the direction of superior conjunction.

U + 180° and B, areocentric longitude and latitude of the Earth referred to the plane of the orbit of *Deimos*, and reckoned from the node.

$u - U$ longitudes of the satellites, reckoned in their orbits from the points which are in superior conjunction with the planet's centre.

Greenwich Noon, 1888.	*Phobos.* a_1	b_1	u_1-U	*Deimos.* a_2	b_2	u_2-U	P	U	B
Mar. 15	18″·14	+ 6″·10	0″·72	45″·41	+ 15″·26	272°·06	36°·29	168°·03	+ 19°·64
16	18·30	6·16	49·76	45·80	15·42	197·38	36·26	167 88	19·68
17	18·46	6·23	98·81	46·19	15·59	122·72	36·23	167·72	19·73
18	18·62	6·30	147·88	46·58	15·76	48·07	36·20	167·54	19·78
19	18·77	6·37	196·95	46·96	15·94	333·43	36·16	167·35	19·84
20	18·92	6·44	246·03	47·34	16·11	258·80	36·12	167·15	19·90
21	19 07	6·51	295·13	47·72	16·29	184·18	36·08	166·93	19·96
22	19·22	6·58	344·24	48·08	16·47	109·58	36 03	166·71	20·03
23	19·36	6·65	33·36	48·44	16 65	34·99	35·98	166·47	20·10
24	19 50	6·73	82·49	48 79	16·83	320 41	35·93	166·22	20·18
25	19·64	6·81	131·63	49·14	17·01	245·84	35·88	165·96	20·26
26	19·77	6·88	180·78	49·48	17·19	171·28	35·82	165·69	20·34
27	19·90	6·95	229·94	49·81	17·38	96·73	35·76	165·40	20·42
28	20·03	7·02	279·11	50·12	17·57	22·19	35·69	165·10	20·51
29	20·15	7·09	328·29	50·43	17·75	307·67	35·62	164·80	20·60
30	20·27	7·17	17·48	50·72	17·93	233·15	35 55	164·49	20·70
31	20·38	7·24	66·68	51·01	18·11	158 64	35·48	164·17	20·80
April 1	20·49	+ 7·31	115·88	51·28	+ 18·29	84·14	35·40	163·83	+ 20·90
2	20·59	7·38	165·09	51·54	18·47	9·65	35·32	163·49	21 00
3	20·69	7·45	214·31	51·78	18·65	295·17	35·24	163·14	21·10
4	20·78	7·52	263·54	52·01	18·82	220·69	35·15	162·78	21·21
5	20·87	7·59	312·77	52·22	18·99	146·22	35·06	162·42	21·32
6	20·95	7·65	2·00	52·42	19·15	71·76	34·97	162·05	21·43
7	21·02	7·72	51·24	52·61	19·31	357·30	34·88	161·67	21·54
8	21·09	7·78	100·48	52·78	19·47	282·85	34·78	161·29	21·65
9	21·15	7·84	149·73	52·93	19·62	208·40	34·68	160·90	21·76
10	21·20	7·90	198·98	53·06	19·77	133·96	34·57	160·51	21·88
11	21·25	7·96	248·23	53·17	19·92	59·51	34·47	160·12	22·00
12	21·29	8·01	297·48	53·27	20·05	345·07	34 36	159·73	22·11
13	21·32	8·06	346·73	53 35	20·18	270·63	34·25	159·34	22·23
14	21·34	8·11	35·98	53·41	20·30	196·19	34·14	158·94	22·34
15	21·36	8·16	85·23	53·45	20·41	121·75	34·03	158 54	22·46
16	21·37	+ 8 20	134·47	53·47	+ 20·52	47·30	33·92	158·15	+ 22 57
17	21·37	8·24	183·71	53·48	20·62	332·85	33·81	157·76	22·68
18	21·37	8·28	232·94	53·47	20·72	258·40	33·69	157·37	22·80
19	21·36	8·31	282·17	53·44	20·80	183·95	33·58	156·99	22·91
20	21·34	8·34	331·40	53·39	20·88	109·49	33·46	156·61	23·02
21	21·31	8·37	20·62	53·33	20·95	35·03	33·35	156·23	23·13
22	21·28	+ 8·39	69·83	53·25	+ 21·01	320·56	33·23	155·86	+ 23·24

Greenwich Noon.	*Phobos.* a_1	b_1	u_1-U	*Deimos.* a_2	b_2	u_2-U	P	U	B
1888.	″	″	″	″	″	°	°	°	°
April 23	21·24	+ 8·41	119·03	53·15	+ 21·06	246·08	33·12	155·50	+ 23·34
24	21·20	8·43	168·23	53·04	21·10	171·59	33·01	155·15	23·45
25	21·15	8·45	217·42	52·91	21·14	97·10	32·90	154·80	23·55
26	21·09	8·46	266·59	52·77	21 17	22·60	32·79	154·46	23·65
27	21·03	8·47	315·76	52·61	21·19	308 09	32 68	154·13	23·75
28	20 96	8·47	4·92	52·44	21·20	233·56	32 58	153·81	23·84
29	20·88	8·47	54·06	52·26	21·20	159 03	32·48	153·50	23·94
30	20·80	8·47	103·19	52·06	21·20	84·49	32·38	153 20	24·03
May 1	20·72	+ 8·47	152·31	51·85	+ 21·19	9 94	32·28	152·92	+ 24 12
2	20·63	8·46	201·42	51·63	21·17	295 37	32·19	152·64	24·21
3	20·54	8·45	250·52	51·40	21·14	220·79	32·10	152·38	24·29
4	20·44	8·44	299·60	51·15	21 11	146·20	32 02	152 13	24·37
5	20 34	8·42	348·67	50·90	21·07	71·59	31·94	151·89	24·45
6	20 24	8·40	37·72	50·64	21·02	356·98	31·86	151·66	24·53
7	20·13	8·38	86·76	50·37	20·97	282·35	31·78	151·45	24·61
8	20·02	8·36	135·78	50·09	20·91	207·70	31·71	151·25	24 68
9	19·90	8·33	184·79	49·80	20·85	133·04	31·65	151·06	24·75
10	19·78	8·30	233·79	49·51	20·78	58 37	31·59	150·89	24·82
11	19·66	8·27	282·77	49·21	20·71	343·68	31·54	150·74	24·89
12	19 54	8·24	331·73	48·91	20·63	268·98	31·49	150·60	24·95
13	19 42	8·21	20·68	48·60	20·55	194·26	31·44	150·47	25 01
14	19·30	8·17	69·61	48·29	20 46	119·53	31·40	150·35	25 07
15	19·17	8·14	118·53	47·97	20·37	44·78	31 37	150·25	25·13
16	19·04	8·10	167·44	47·65	20·27	330·02	31·34	150·17	25·18
17	18·91	8·06	216·33	47·33	20·17	255·24	31·32	150 10	25·23
18	18·78	8·02	265·20	47·00	20·07	180·45	31·30	150·05	25·28
19	18·65	7·98	314·06	46·67	19·96	105·64	31·29	150·01	25·33
20	18·52	7·93	2·90	46·34	19·85	30·82	31·28	149·98	25·37
21	18·39	7 89	51·72	46·01	19·74	315·99	31·28	149·97	25·41
22	18·25	7·84	100·53	45·68	19·63	241·14	31·28	149 97	25·45
23	18·12	7·80	149·33	45·35	19 51	166·27	31·29	149·99	25·49
24	17·99	7·75	198·11	45·02	19·39	91·39	31·30	150 02	25·52
25	17·86	7·70	246·88	44·68	19 27	16·50	31·32	150·07	25·55
26	17·72	7·65	295·64	44·35	19·15	301·60	31·34	150·13	25·58
27	17·59	7·60	344·38	44·02	19·03	226·68	31·37	150·20	25·61
28	17·46	7·55	33·11	43·69	18·90	151·75	31·40	150·29	25·63
29	17·33	7·50	81·82	43·37	18·78	76·80	31·44	150·39	25·66
30	17·20	+ 7·45	130 52	43·04	+ 18 65	1·84	31·48	150·50	+ 25·68

These values are to be interpolated directly for the times for which the positions of the satellites are required, the equation of light having already been taken into account in the ephemeris. The position-angles p and distances s are then found by means of the formulæ

$$s \sin (p - \mathrm{P}) = a \sin (u - \mathrm{U})$$
$$s \cos (p - \mathrm{P}) = b \cos (u - \mathrm{U}).$$

The satellites move in the direction of increasing position-angles, and will be at their greatest eastern and western elongations (e in position P + 90° and w in position P − 90°) about the following Greenwich mean times:—

	Phobos.		*Deimos.*		*Phobos.*		*Deimos.*
1888.	h	h	h	1888.	h	h	h
Mar. 15	13·4 *w*	17·2 *e*	15·0 *e*	Apr. 12	10·9 *e*	14·7 *w*	8·8 *e*
16	12·3 *w*	16·2 *e*	21·2 *e*	13	9·8 *e*	13·7 *w*	15·1 *e*
17	11·3 *w*	15·1 *e*	12·4 *w*	14	8·8 *e*	12·6 *w*	6·2 *w*
18	14·1 *e*	17·9 *w*	18·7 *w*	15	11·6 *w*	15·4 *e*	12·5 *w*
19	13·0 *e*	16·9 *w*	9·8 *e*	16	10·5 *w*	14·4 *e*	18·7 *w*
20	12·0 *e*	15·8 *w*	16·1 *e*	17	9·5 *w*	13·3 *e*	9·8 *e*
21	10·9 *e*	14·8 *w*	7·2 *w*	18	8·4 *w*	12·3 *e*	16·1 *e*
22	13·7 *w*	17·6 *e*	13·5 *w*	19	11·2 *e*	15·0 *w*	7·2 *w*
23	12·7 *w*	16·5 *e*	19·8 *w*	20	10·2 *e*	14·0 *w*	13·5 *w*
24	11·6 *w*	15·5 *e*	10·9 *e*	21	9·1 *e*	13·0 *w*	19·7 *w*
25	10·6 *w*	14·4 *e*	17·2 *e*	22	8·1 *e*	11·9 *w*	10·9 *e*
26	13·4 *e*	17·2 *w*	8·3 *w*	23	10·9 *w*	14·7 *e*	17·1 *e*
27	12·3 *e*	16·2 *w*	14·6 *w*	24	9·8 *w*	13·6 *e*	8·3 *w*
28	11·3 *e*	15·1 *w*	20·8 *w*	25	8·8 *w*	12·6 *e*	14·5 *w*
29	10·2 *e*	14·1 *w*	12·0 *e*	26	11·5 *e*	15·4 *w*	20·8 *w*
30	13·0 *w*	16·8 *e*	18·2 *e*	27	10·5 *e*	14·3 *w*	11·9 *e*
31	12·0 *w*	15·8 *e*	9·4 *w*	28	9·5 *e*	13·3 *w*	18·2 *e*
Apr. 1	10·9 *w*	14·8 *e*	15·6 *w*	29	8·4 *e*	12·2 *w*	9·3 *w*
2	9·9 *w*	13·7 *e*	6·7 *e*	30	11·2 *w*	15·0 *e*	15·6 *w*
3	12·7 *e*	16·5 *w*	13·0 *e*	May 1	10·2 *w*	14·0 *e*	6·7 *e*
4	11·6 *e*	15·4 *w*	19·3 *e*	2	9·1 *w*	12·9 *e*	13·0 *e*
5	10·6 *e*	14·4 *w*	10·4 *w*	3	8·1 *w*	11·9 *e*	19·3 *e*
6	9·5 *e*	13·3 *w*	16·7 *w*	4	10·8 *e*	14·7 *w*	10·4 *w*
7	12·3 *w*	16·1 *e*	7·8 *e*	5	9·8 *e*	13·6 *w*	16·7 *w*
8	11·3 *w*	15·1 *e*	14·0 *e*	6	8·8 *e*	12·6 *w*	7·8 *e*
9	10·2 *w*	14·0 *e*	20·3 *e*	7	11·5 *w*	15·4 *e*	14·1 *e*
10	9·2 *w*	13·0 *e*	11·4 *w*	8	10·5 *w*	14·3 *e*	5·2 *w*
11	11·9 *e*	15·8 *w*	17·7 *w*	9	9·5 *w*	13·3 *e*	11·5 *w*

	Phobos.	*Deimos.*		*Phobos.*	*Deimos.*
1888.	h	h	1888	h	h
May 10	8·4 *w*	12·2 *e* 17·8 *w*	May 19	10·5 *e*	14·4 *w* 13·8 *w*
11	11·2 *e*	15·0 *w* 8·9 *e*	20	9·5 *e*	13·3 *w* 5·0 *e*
12	10·2 *e*	14·0 *w* 15·2 *e*	21	8·5 *e*	12·3 *w* 11·3 *e*
13	9·1 *e*	13·0 *w* 6·4 *w*	22	11·3 *w*	15·1 *e* 17·6 *e*
14	8·1 *e*	11·9 *w* 12·7 *w*	23	10·2 *w*	14·0 *e* 8·7 *w*
15	10·9 *w*	14·7 *e* 18·9 *w*	24	9·2 *w*	13·0 *e* 15·0 *w*
16	9·8 *w*	13·7 *e* 10·1 *e*	25	8·1 *w*	12·0 *e* 6·2 *e*
17	8·8 *w*	12·6 *e* 16·4 *e*	26	7·1 *w*	10·9 *e* 12·5 *e*
18	7·8 *w*	11·6 *e* 7·5 *w*	27	9·9 *e*	13·7 *w* 18·8 *e*

As *Deimos* has been observed with the 15-inch refractor of Harvard College on January 10, 1880, when the log. of the light-ratio of *Mars* was only 9·530 (corresponding to that of March 1 and June 13, 1888), there should be no difficulty of securing at least a few observations of both satellites by the more powerful instruments which are at present available.

Ephemeris of the Satellites of Uranus, 1888. By A. Marth.

	Ariel.				*Umbriel.*				
Greenwich, Noon.	a_1	b_1	u_1-U	Diff.	a_2	b_2	u_2-U	Diff.	P
1888.	″	″	°	°	″	″	°	°	°
Feb. 22	14·99	+7·58	238·59	1428·38	20·88	+10·56	94·65	868·69	283·677
Mar. 3	15·08	7·56	226·97	·36	21·01	10·53	243·34	·66	283·735
13	15·15	7·51	215·33	·33	21·11	10·46	32·00	·65	283·802
23	15·20	7·44	203·66	·30	21·18	10·36	180·65	·62	283·874
Apr. 2	15·22	7·35	191·96	·27	21·20	10·24	329·27	·61	283·947
12	15·21	7·25	180·23	·26	21·20	10·10	117·88	·60	284·019
22	15·18	7·14	168·49	·24	21·15	9·95	266·48	·60	·086
May 2	15·13	+7·02	156·73	·22	21·07	+9·79	55·08	·59	·146
12	15·05	6·91	144·95	·22	20·96	9·63	203·67	·59	·196
22	14·95	6·80	133·17	·22	20·83	9·48	352·26	·59	·235
June 1	14·84	6·71	121·39	·22	20·67	9·34	140·85	·60	·262
11	14·72	6·62	109·61	·23	20·50	9·23	289·45	·61	·277
21	14·59	6·56	97·84	·23	20·32	9·13	78·06	·62	·279
July 1	14·45	6·51	86·07	1428·25	20·13	9·07	226·68	868·64	·267
11	14·32	+6·48	74·32		19·95	+9·03	15·32		284·242

	Titania.				*Oberon.*				
	a_2	b_2	u_2-U	Diff.	a_4	b_4	u_4-U	U	B
1888.	"	"	°	°	"	"	°	°	°
Feb. 22	34·26	+17·31	343·82	413·48	45·81	+23·15	147·18	1·726	+30·36
Mar. 3	34·47	17·26	37·30	·46	46·09	23·09	54·53	1·783	30·06
13	34·63	17·16	90·76	·45	46·31	22·94	321·87	1·849	29·70
23	34·73	17·00	144·21	·45	46·45	22·73	229·20	1·921	29·30
Apr. 2	34·78	16·80	197·66	·44	46·51	22·47	136·52	1·995	28·88
12	34·77	16·57	251·10	·43	46·49	22·16	43·84	2·068	28·46
22	34·69	16·31	304·53	·44	46·39	21·82	311·16	2·136	28·05
May 2	34·56	+16·05	357·97	·44	46·22	+21·46	218·48	2·197	+27·67
12	34·38	15·79	51·41	·45	45·98	21·12	125·81	2·249	27·34
22	34·16	15·54	104·86	·45	45·68	20·79	33·15	2·289	27 07
June 1	33·91	15·32	158·31	·46	45·34	20·49	300·50	2·316	26·87
11	33·62	15·13	211·77	·48	44·97	20·24	207·86	2·329	26·75
21	33·33	14·98	265·25	·49	44·57	20·04	115·23	2·326	26·71
July 1	33·03	14·87	318·74	413·50	44·17	19·89	22·61	2·308	26·77
11	32·73	+14·81	12·24		43·77	+19·80	290·01	2·278	+26·91

The notation is the same as in the ephemeris of the satellites of *Mars*.

The four satellites of *Uranus* are assumed to move in the same plane, the ascending node N and inclination J of which in reference to the celestial equator of 1880·0 are assumed to have the values

$$N = 165°·770; \quad J = 75°·210.$$

The satellites move in the direction of increasing position-angles, and will be at their greatest elongations (N. in position-angle P+90°, S. in position P−90°) and at their conjunctions (superior conjunction in position P, inferior conjunction in position P−180°) with the centre of the planet at the following Greenwich mean times :—

Ariel.

	N. Elong.		S. Elong.			N. Elong.		S. Elong.			N. Elong.		S. Elong.	
1888.	h		h			h		h			h		h	
Feb. 26	0·0		27	6·3	Mar. 19	16·4		20	22·7	Apr. 11	8·8		12	15·1
28	12·5		28	18·7	22	4·9		23	11·1	13	21·3		15	3·6
Mar. 2	1·0		3	7·2	24	17·4		25	23·6	16	9·8		17	16·1
4	13·5		5	19·7	27	5·9		28	12·1	18	22·3		20	4·6
7	2·0		8	8·2	29	18·4		31	0·6	21	10·8		22	17·1
9	14·5		10	20·7	Apr. 1	6·9		2	13·1	23	23·3		25	5·5
12	2·9		13	9·2	3	19·4		5	1·6	26	11·8		27	18·0
14	15·4		15	21·7	6	7·9		7	14·1	29	0·3		30	6·5
17	3·9		18	10·2	8	20·3		10	2·6	May 1	12·8		2	19·0

1888.	N. Elong. h	S. Elong. h		N. Elong. h	S. Elong. h		N. Elong. h	S. Elong. h
May 4	1·3	5 7·5	May 26	17·7	28 0·0	June 18	10·2	19 16·4
6	13·8	7 20·0	29	6·2	30 12·5	20	22·7	22 4·9
9	2·3	10 8·5	31	18·7	Ju. 2 1·0	23	11·2	24 17·4
11	14·8	12 21·0	June 3	7·2	4 13·5	25	23·7	27 5·9
14	3 3	15 9·5	5	19·7	7 2·0	28	12·2	29 18·4
16	15·8	17 22·0	8	8·2	9 14·5	July 1	0·7	2 6·9
19	4·2	20 10·5	10	20·7	12 3·0	3	13·2	4 19·4
21	16·7	22 23·0	13	9·2	14 15·4	6	1·6	7 7·9
24	5 2	25 11·5	15	21·7	17 3·9	8	14·1	9 20·4

Umbriel.

Feb. 26	2·2	28 3·9	Apr. 11	16·3	13 18·0	May 27	6·5	29 8·2
Mar. 1	5·6	3 7·4	15	19·8	17 21·5	31	9·9	Ju. 2 11·7
5	9·1	7 10·8	19	23·2	22 1·0	June 4	13·4	6 15·2
9	12·6	11 14·3	24	2·7	26 4·4	8	16·9	10 18·6
13	16·0	15 17·8	28	6·2	30 7·9	12	20·4	14 22·1
17	19·5	19 21·2	May 2	9·6	4 11·4	16	23·8	19 1·6
21	23·0	24 0·7	6	13·1	8 14·9	21	3·3	23 5·0
26	2·4	28 4·2	10	16·6	12 18·3	25	6·8	27 8·5
30	5·9	Ap. 1 7·6	14	20·1	16 21·8	29	10·2	Jy. 1 12·0
Apr. 3	9·4	1 11·1	18	23·5	21 1·3	July 3	13·7	5 15·4
7	12·8	9 14·6	23	3·0	25 4·7	7	17·2	9 18·9

Titania.

1888.	h			h		h			h
Feb. 22	9·4	sup.	Mar. 28	5·3	May 2	1·2	sup.	June 5	21·1
24	13·6	N.	30	9·5	4	5·4	N.	8	1·3
26	17·9	inf.	Apr. 1	13·7	6	9·7	inf.	10	5·6
28	22·1	S.	3	18·0	8	13·9	S.	12	9·8
Mar. 2	2·4	sup.	5	22·2	10	18·2	sup.	14	14·0
4	6·6	N.	8	2·5	12	22·4	N.	16	18·3
6	10·8	inf.	10	6·7	15	2·6	inf.	18	22·5
8	15·1	S.	12	11·0	17	6·9	S.	21	2·8
10	19·3	sup.	14	15·2	19	11·1	sup.	23	7·0
12	23·6	N.	16	19·5	21	15·4	N.	25	11·2
15	3·8	inf.	18	23·7	23	19·6	inf.	27	15·5
17	8·0	S.	21	4·0	25	23·9	S.	29	19·7
19	12·3	sup.	23	8·2	28	4·1	sup.	July 1	23·9
21	16·5	N.	25	12·4	30	8·3	N.	4	4·2
23	20·8	inf.	27	16·7	June 1	12·6	inf.	6	8·4
26	1·0	S.	29	20·9	3	16·8	S.	8	12·7

Oberon.

1883.	h			h		h			h.
Feb. 16	11·9	sup.	Mar. 27	21·4	May 7	7·0	sup.	June 16	16·6
19	20·7	N.	31	6·2	10	15·8	N.	20	1 4
23	5·5	inf.	Apr. 3	15·0	14	0·6	inf.	23	10·1
26	14·3	S.	6	23·8	17	9·4	S.	26	18·9
29	23·0	sup.	10	8·6	20	18·2	sup.	30	3·7
Mar. 4	7·8	N.	13	17·4	24	3·0	N.	July 3	12·5
7	16·6	inf.	17	2·2	27	11·8	inf.	6	21·3
11	1·4	S.	20	11·0	30	20·6	S.	10	6·0
14	10·2	sup.	23	19·8	June 3	5·4	sup.		
17	19·0	N.	27	4·7	6	14·2	N.		
21	3·8	inf.	30	30·5	9	23·0	inf.		
24	12·6	S.	May 3	22·3	13	7·8	S.		

Titania and *Oberon* will appear in a line with the centre of the planet at the following times :—

In opposite directions of the centre—

	h		h		h
Feb. 20	20·7	Apr. 10	3·2	May 29	9·9
Mar. 16	11·9	May 4	18·5	June 23	1·2

And in the same direction from the centre—

	h		h		h
Mar. 4	4·3	Apr. 22	10·9	June 10	17·6
28	19·6	May 17	2·2	July 5	8·9